Reply to Gaillard

Laura Schild & Ulrike Herzschuh

General reply

Dear Marie-José Gaillard,

We thank you for your extensive review of our manuscript and the constructive comments. While you welcome our work towards global pollen-based vegetation reconstructions and do not criticize the general method you stated helpful comments regarding some concerns. We think that all of them are easily remediable and changes are feasible or have already been implemented by us .

Large basins provide great value to large-scale reconstructions and site-wise reconstructions will only be kept if the original basin is of sufficient size (>= 50ha). We do agree with and recognize the limited suitability of small basins for site-wise reconstructions. Our previous intention was to create a dataset that could be gridded at different resolutions desired by the user, which we did not emphasize enough in our manuscript. We believe this flexibility would improve the usefulness of the reconstructions. To still acknowledge and highlight potential downfalls here, it is pertinent to both flag unreliable, small basins in the data set and provide a detailed description of potential uses and an adjustable script for rasterization. We will implement this in our revisions. Additionally, any non-lake or peat basins will be removed from the data set as they are unfitting for reconstruction by REVEALS.
The naming of our calculated source area is indeed unfortunate and will be changed. We will also expand on its calculation and usability in the manuscript text. Additionally, new RPP studies will be added to our synthesis and the descriptor “original values” changed to “synthesis values”.

We are confident in the feasibility of these adjustments, as we have already been able to implement the majority of them, and believe it will improve the clarity of the manuscript greatly. Below we respond in detail to each major issue raised and the detailed comments.

Best regards
Laura Schild and Ulrike Herzschuh

Specific replies

Major Issues

Pollen records appropriate for the application of the REVEALS model to reconstruct REGIONAL plant cover

Original comment

1. The REVEALS model was developed to reconstruct REGIONAL plant cover using pollen records from LARGE LAKES, alternatively multiple SMALL LAKES (Sugita 2007a, REVEALS model). Trondman et al. (2016) (VHA) tested the REVEALS model using MULTIPLE SMALL SITES (lakes and bogs) and concluded that pollen records from MULTIPLE SMALL BOGS could be used, ideally in mixture with pollen records from LARGE and/or SMALL lakes. Thus:
2. The REVEALS model is NOT appropriate to reconstruct regional plant cover using pollen records from SINGLE SMALL sites (lakes or bogs) and from LARGE BOGS (single or multiple). See Sugita (2007a, REVEALS model) for the definition of large lake, and Trondman et al. (2015) for the choice of 50 ha as a "practical" delimitation between small (< 50 ha) and large (>50 ha) sites.
3. The REVEALS model IS appropriate to reconstruct plant cover using pollen records from SINGLE LARGE LAKES (however always better with records from SEVERAL LARGE LAKES in the same vegetation region); and it is also appropriate using pollen records from MULTIPLE SMALL LAKES (Sugita 2007a REVEALS model) and from a mixture of SMALL SITES (bogs and lakes) (Trondman et al., 2016).
4. In the LandCover6k protocol, LARGE BOGS are used, but the reconstructions are considered as not or less reliable (information provided in the publications) if they include: (1) only one large bog record, (2) several large bog records and no lake record or too few lake records relative to the number of large bog records.
5. The REVEALS model is NOT appropriate using pollen records from marine sediments or other types of sites receiving large amounts of pollen from rivers or surface run-off. The LandCover6k reconstructions have excluded marine and large deltas pollen records. Pollen records from lagunes that are sufficiently sheltered from the sea can be used.
6. **All the points made above, and the first point made below, imply that** (1) the dataset of single site REVEALS estimates of plant cover CANNOT BE USED AS SUCH as each REVEALS reconstruction from a single small site (bog or lake) and a single large bog is incorrect; (2) Only REVEALS estimates using pollen records from single LARGE LAKES or REVEALS **MEAN** ESTIMATES based on the REVEALS estimates from **MULTIPLE SITES** are correct and can therefore be used. This also implies that IF THIS DATASET IS MADE OPEN ACCESS FOR USE, **it MUST BE CLARIFIED for the user what can be done AND NOT DONE with these single sites REVEALS estimates**, i.e. (1) one CANNOT use the original single site REVEALS plant cover if the pollen record is from a SMALL SITE (lake or bog) or a LARGE BOG. (2) one **CAN** calculate **MEAN REVEALS estimates** within regions from ca. 50 km x 50 km (se Hellman et al., 2008b in VHA and Trondman et al., 2015 in GCB) up to whole regions or continents (the latter continental scale is provided in Schmid et al.'s dataset, but nothing else).

Reply

Our site-wise reconstructions using large lakes are still valid and their information can be used in gridded versions of this data set. We agree and recognize that reconstructions from small lakes and peatland sites should not be used alone as site-wise reconstructions. Our validation

will be adjusted to also use these sites aggregated in grid cells and not individually. Figures 1-3 below show different validations, some of which were , one with all records used as a site-wise reconstruction (incorrect validation, Fig 1, newly created), one where only large lakes are used for a site-wise validation (Fig 2, newly created) and one where all data is aggregated in 5x5° grid cells, which are used for validation (Fig 3, newly created). With the exception of Asia, aggregation in grid cells lowers the calculated mean absolute error even further and **highlights the reliability and validity of these aggregated reconstructions**.
Our aim is for the data set to be used flexibly, meaning that users can set their own temporal and spatial resolution for rasterization.This is why we did not prepare a set rasterization. To highlight this use case we will **provide a script to rasterize the dataset dynamically and classify grid cell reliability by record availability**. Additionally, we will expand on this in our data usability section and clarify how we intend the data set to be used reliably. Small sites and peatland will also receive an additional flag in the data set.

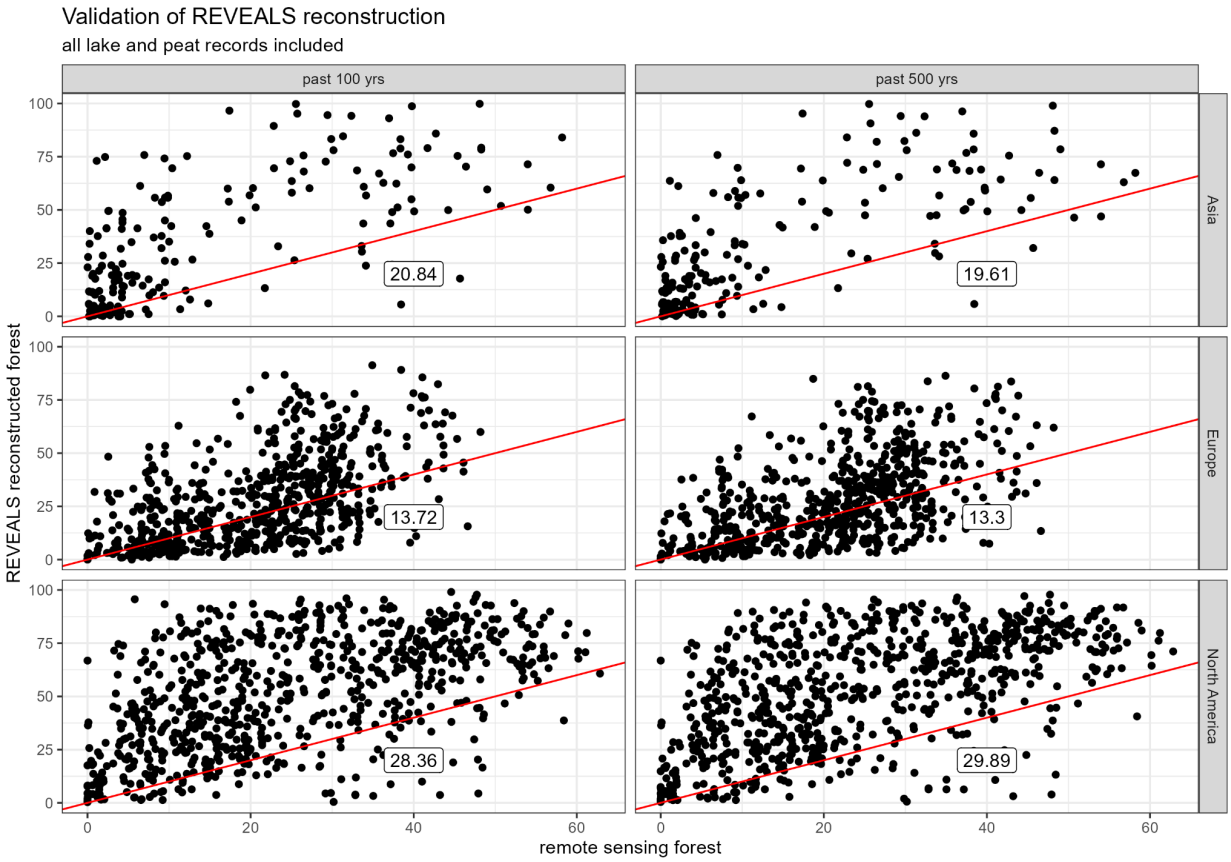

Fig 1: *(newly created)* Site-wise validation of reconstructed forest cover at all lake and peat records in Asia, Europe, and North America. Two age intervals were used for the calculation of a “modern” site average forest cover. The label shows the mean absolute error for each subset. This is the validation akin to the one used in our manuscript (with an exclusion of non-peat and non-lake sites). **The smaller modern interval changes error values only marginally. These values can be compared to the following two validations, which follow better practice, to see how the calculated MAE was potentially impacted.**

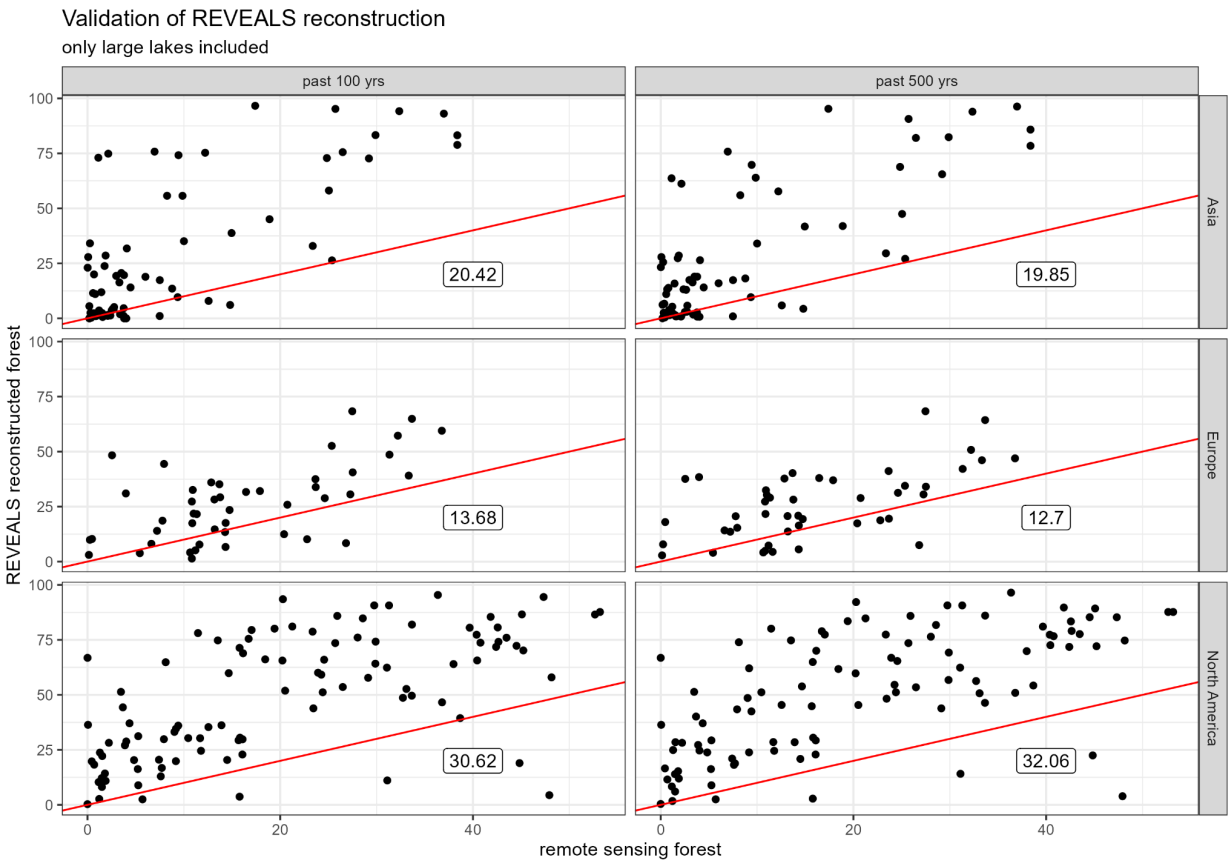

Fig 2: *(newly created)* Site-wise validation of reconstructed forest cover at all large lake sites (>= 50ha) in Asia, Europe, and North America. Two age intervals were used for the calculation of a "modern" site average forest cover. The label shows the mean absolute error for each subset. **This site-wise validation even shows slightly smaller errors for European sites. MAE values in Asia and North America are slightly larger. The now smaller sample size could also impact this. Error values are slightly larger in the shorter modern interval with the exception of North America. Removing small sites from the site-wise validation does not impact it significantly.**

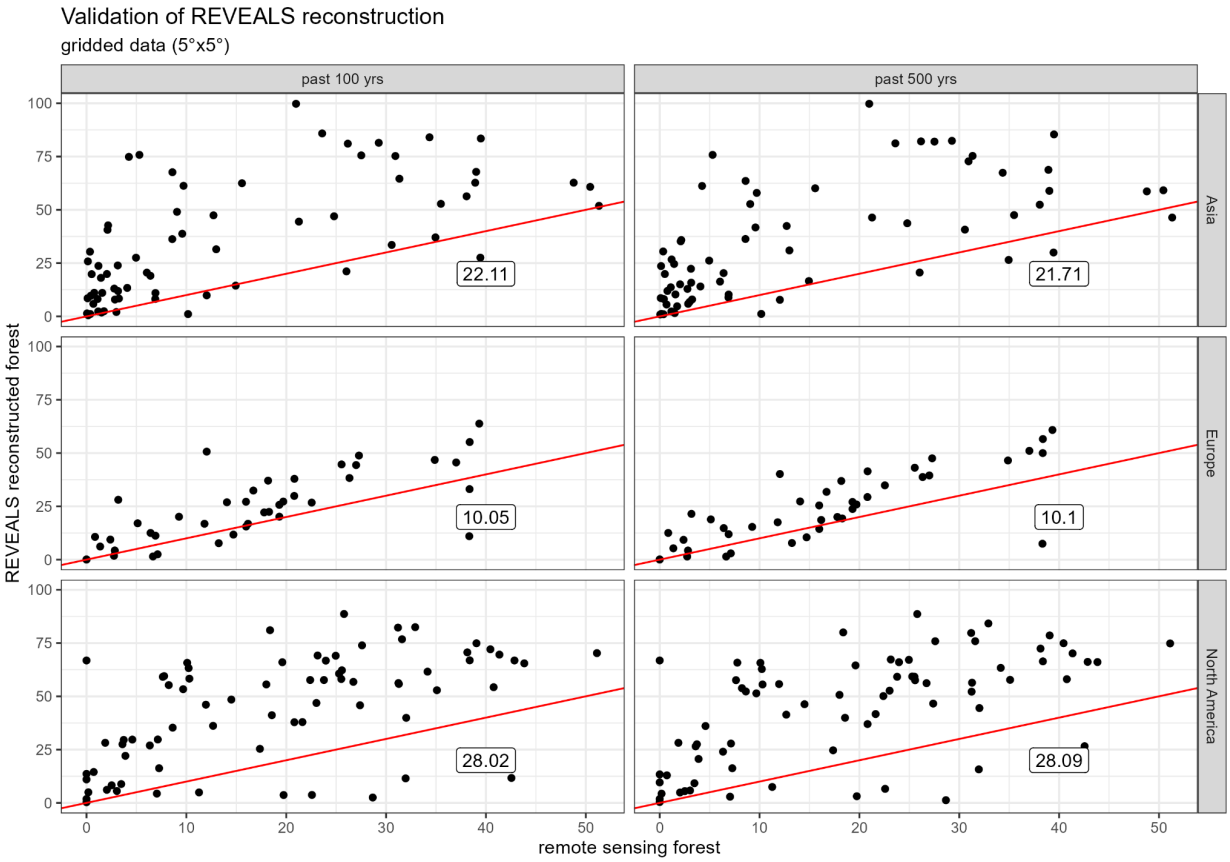

Fig 3: *(newly created)* Grid-cell wise validation of reconstructed forest cover in Asia, Europe, and North America. Two age intervals were used for the calculation of a "modern" cell average forest cover. The label shows the mean absolute error for each subset. **This gridded validation shows smaller errors compared to the original site-wise validation (Fig 1) and the corrected site-wise validation (Fig 2). Only MAE values in Asia are slightly larger. Spatial averages of our data set, therefore, do not impact the quality.**

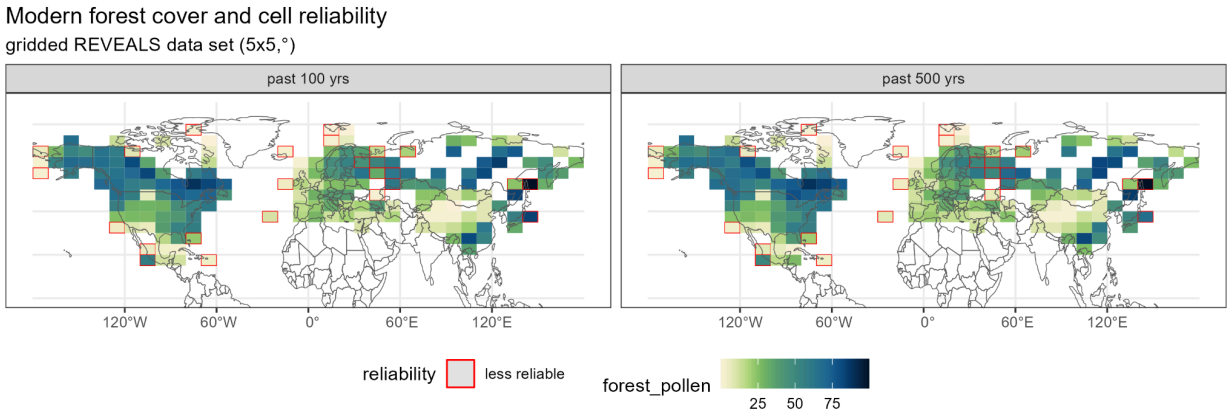

Fig 4: Reconstructed forest cover and reliability of grid cell results for two modern intervals. The cell fill indicates the forest cover as reconstructed with REVEALS results without the openness correction applied for validation. Grid cells outlined in red include no large lake and less than two small basins (small lakes or peatlands) and are therefore considered to be less reliable. This example rasterization has a resolution of 5x5°. **A gridded version of our data set still achieves good spatial coverage with only few cells having a lower reliability. A figure showing the reliability through time could also be added to this.**

Implementation of the REVEALS model and pollen source areas

Original comment

7. This first point is also relevant for the issue discussed above: The authors (Schild et al.) use Theuerkauf et al. (2016) "REVEALSinR" to implement the REVEALS model as an alternative to Sugita's REVEALS programme (last revised in 2022) or the R REVEALS program by Petr Kunes. The use of "REVEALSinR" implies that the REVEALS model assumptions (Sugita 2007a; further discussed and explained in e.g., Githumbi et al. (2022), Li et al. (2020; 2023) must be considered while implementing the model. For example, the selection of appropriate sites and the number of pollen records used for the reconstruction are essential. If using pollen records from SMALL sites, the larger the number of sites/pollen records the better. The use of a single small site or a single LARGE BOG will provide biased reconstructions that won't be useful for the analysis of past plant cover, neither at the regional scale nor at the local scale. For instance, Theuerkauf et al. 2016 write: "*Like the original REVEALS programme, 'REVEALSinR' includes a function to address deposition in lakes (for details see ESM). Both the original REVEALS programme and 'REVEALSinR' only consider atmospheric pollen deposition (and lake mixing); neither model is applicable to sites that receive significant amounts of pollen from rivers, streams or surface run-off*". Theuerkauf et al. (2016) do not say explicitly that REVEALS can be used with pollen records from SINGLE small sites. But, very unfortunately, they confuse the reader by introducing severe misunderstandings in their description of the REVEALS model and its application (selection of pollen records). For instance (under "Principles of 'REVEALSinR'": "*The REVEALS model (Sugita 2007a) is based on the assumption that pollen deposition of a plant taxon in a large lake or **peatland** is equal to the mean abundance of that taxon in the region, multiplied by its pollen productivity and its 'pollen dispersal-deposition coefficient' K*….etc". Sugita 2007a calls his model REVEALS, i.e. Regional Estimates of Vegetation Abundance from Large **Sites" BUT** it is developed for pollen deposited in **LAKES** and tested theoretically with simulated pollen records from **LAKES**. Further, one of the assumptions of the REVEALS model is that **the deposition basin is NOT COVERED BY VEGETATION**. It follows, therefore, that REVEALS is not appropriate for pollen records from large bogs. Another unfortunate issue in Theuerkauf et al. (2016) is the use of small sites in one of the tests of the effect of different pollen dispersal models on the REVEALS reconstruction, **although the second experiment uses a pollen record from a LARGE LAKE, which is correct!**, i.e., (under Materials and Methods, in relation to the first experiment): "*We associate the record with lakes and peatlands of different size (100–10,000 m in diameter), using different cut-off distances for the tail of the GPM (50 km to infinity). This cut-off sets an arbitrary limit to the maximum distance pollen may travel (the region considered as pollen source area). The cut-off for the LSM is set to 100 km, which is the calculated average distance at which 95 % of the pollen has settled (cf. Fig. 1)*." The latter implies that the authors use REVEALS for single sites from 1 to 100 ha. Moreover, they use the fact that the "Radius of the 80 % source area of pollen" for sites of 1 ha or 100 ha are not significantly different to argue that what makes the largest difference between sites of different size is the pollen dispersal model. This is true for the "pollen source area" defined as the characteristic radius for 80% or 90% etc.… of the pollen reaching the site, but it is NOT true for the size of the area a quantitative pollen reconstruction of plant cover represents when pollen records are from **SMALL SITES. See the LOVE model (Sugita 2007b) and definition of RSAP (Sugita, 1994). This is a typical example of what a published paper having got weak**

reviews may lead to in studies by scientists that do not go back to the sources, in this case the description of the REVEALS model by its author!..... A good scientist should know that all what's published is not necessarily correct, especially today as the review system is close to collapse due to a too large article production in comparison to the number of reviewers that have the appropriate expertise to evaluate a new study. GO BACK TO THE ORIGINAL SOURCES!

Reply

As outlined above, we agree that peatland sites as well as small lakes are unsuitable for a site-wise reconstruction, which is why we will **aggregate them in grid cells and highlight in the manuscript that this is the intended use case**. This will be supplemented by a script to create flexibel rasterized data sets.
Additionally, the 80% pollen source area is indeed less informative if calculated from small sites. We will **remove calculated values from the small lake and peatland sites** in our data set.
Of course we do not intend to recreate the RSAP as defined by Sugita in our data set creation, but the area where 80% of pollen originates from. The overlap in naming is indeed unfortunate, which is why we see no problem **changing the name of our calculated parameter** to "80% pollen source area".

Original Comment

8. The authors of the discussed paper (Schmid et al.) claim that they are calculating the "RELEVANT SOURCE AREA" of each site, small and large (although it says RELATIVE pollen source area in the abstract". It is unclear how this is calculated. Under 2.2.2 it says, *"We calculate the radius of relevant pollen source area by FINDING THE RADIUS IN WHICH THE MEDIAN INFLUX OF ALL TAXA IS 80% OF THE TOTAL INFLUX (as defined by the total influx in the MAXIMUM extent of REGIONAL VEGETATION CHOSEN)".* This seems to be the source area of pollen as defined by Theuerkauf et al (2016). **This in any case NOT the RELEVANT SOURCE AREA OF POLLEN (RSAP)**. RSAP was defined originally by Sugita (1994, Ecology) and can only be estimated for SMALL SITES using the LOVE model (backwards modelling approach; Sugita 2007b The LOVE model) or the ERV model and a forward modelling approach (Hellman et al., 2009, R. Pal. Pal). **The RSAP is the minimum size of the area for which the LOVE estimates of plant cover using pollen records from SMALL SITES is valid.** The maximum size of the area cannot be calculated. The definition of the pollen source area by Schmid et al. mentioned above seems to correspond to the "characteristic radius" approach first described by Prentice (1988). This method is generally used to estimate the parameter *Zmax* needed to apply the REVEALS model (see examples in Hellman et al. 2008b in VHA; and in Gaillard et al. 2022, see Figure below). Zmax is defined as the maximum extent of the regional vegetation and is not estimated in the REVEALS programme by Sugita. *Zmax* is not the same as RSAP and it is not either necessarily the size of the area for which a REVEALS plant cover reconstruction (using appropriate pollen records!) is valid (or most valid). See point 9 below.

From Supplementary Material for Gaillard, M.-J. Githumbi, E., Achoundong, G., Lézine, A.-M., Hély, C., Lebamba, J., Marquer, L., Mazier, F., Li, F., and Sugita, S. (2021). "The challenge of pollen-based quantitative reconstruction of Holocene plant cover in tropical regions: A pilot study in Cameroon." In: Runge, J., Gosling, W., Lézine, A.-M., and Scott, L. (eds) Quaternary Vegetation Dynamics. The African Pollen Database, pp. 183- 1518 205. CRC Press. eBook ISBN9781003162766, Taylor and Francis Group. https://doi.org/10.1201/9781003162766-12

"Z_{max} (distance within which most pollen comes from) is a parameter needed to apply the ERV model (see equation above). A way to estimate this distance is to calculate the "characteristic radius" (CR) sensu Prentice (1988) for each taxon involved in the ERV analysis and for the "basin size" (or radius) of

the sample site (0.5 m for soil samples, lake size for sediment samples) using the taxa FSP (e.g. Hellman et al., 2008b). We calculated CR using Prentice's bog model (GPM) and the Sutton's parameters cz (vertical diffusion coefficient, 0.12); cy (horizontal diffusion coefficient, 0.21), n (empirical coefficient, 0.25), and u (wind speed, 3 m/s).The CR of the 12 taxa used in this study (Table 2, above) for a basin size of 0.5 m (soil sample) (Figure 1) implies that 90% of three pollen taxa are coming from > 200 km (e.g. Moraceae, ca. 250 km) and 90% of nine pollen taxa are coming from < 200 km (e.g. Syzygium, ca. 290 km (max CR); Macaranga, ca. 150 km; Podocarpus, ca. 100 km; Poaceae, ca. 20 km (min CR)). ≤ 85% of all 26 taxa used in the first ERV model run come from ≤ 200 km (all results not shown here). Therefore, Z_{max} was set to 200 km."

9. Theuerkauf et al. (2016) also discuss the size of the area represented by REVEALS estimated plant cover (under Discussion): "*REVEALS output is commonly interpreted as representing the regional vegetation composition— but how large is this region? Or, where does the pollen come from? There is no simple answer because pollen arrives from nearby as well as far away, with nearby sources contributing (much) more (Janssen 1966). Prentice and Webb (1986) suggested approximating the source area as the area outside the basin from which e.g. 80 % of total pollen deposition arrives. For large lakes and peatlands with 1,000 m diameter (***MJG: e.g. large sites***!), the LSM predicts that the size of the 80 % source area is *55 km for all taxa, whether with high or low fall speed. In contrast, the conventional GPM for neutral conditions predicts a large difference in the 80 % source area of taxa with low (*120 km) and taxa with high fall speed (12 km; Table 1). Whereas the unrealistic GPM defies definition of a distinct source area, the realistic LSM offers a clear delineation." (……).* The latter result is perfectly logical but does not mean that it is not possible to define a pollen source area with the definition "*the area outside the basin from which e.g. 80 % of total pollen deposition arrives".* In the results presented by Theuerkauf et al. (2016) **the pollen source area is ca 55 km in diameter with the LSM and for the GPM it is maximum 120 km (i.e. distance for the low fall speed pollen, the distance for the high fall speed pollen being smaller, but for ALL the pollen types together, the max distance becomes 120 km.**

10. On the subject of "the size of the area represented by REVEALS estimated plant cover", Shinya Sugita writes in Li et al. (2022; pages 4-5): "*When REVEALS is applied using pollen records from multiple sites, one of the important assumptions is that there is no spatial gradients in vegetation composition within the multiple sites region (Sugita, 2007a). In addition, it is assumed (and computer simulations support it) that,* ***when the basin size is >100 ha, the site-to-site variation of pollen assemblages becomes negligible even if the spatial structure of vegetation is highly patchy (Sugita, 2007a).*** *Accordingly,* ***the averaged values*** *of the REVEALS estimates using pollen records from* ***multiple large sites*** (**MJG: and multiple small sites, see Hellman et al., 2016**) ***approximate the species composition of the regional vegetation reasonably well*** *as simulations and empirical studies have demonstrated (e.g. Hellman et al., 2008a, b). In theory and practice, however, the strict definition of the pollen source area is difficult for REVEALS application.* ***Sugita (2007a) defined it as the area within which most of the pollen comes from (Zmax).*** *Simulations and previous empirical studies (e.g. Sugita, 2007a, b; Hellman et al., 2008b; Sugita et al., 2010; Mazier et al., 2012)* ***have indicated that, when the radius of the source area defined varies from 50 km to 400 km, the REVEALS results of regional vegetation reconstruction do not change significantly.*** *The basin size is potentially important for REVEALS-based estimate of regional vegetation because differences in basin size among sites can lead to a significant site-to-site variation in the pollen assemblages.* ***However, as long as the multiple study sites are located within a region that satisfies the first assumption as described above (no gradients in the overall vegetation composition), the averaged REVEALS estimates effectively represent the regional vegetation composition as demonstrated in Hellman et al., 2008a.*** *The accuracy of the reconstructed vegetation against the observed vegetation composition was assessed for areas of 50 km × 50 km and 100 km × 100 km around each site in two regions of southern Sweden. The pollen records used are from 5 large lakes in each region, thus 10 lakes in total, that vary in size between 76 ha and 1965 ha. The results support the main conclusions and implications for the REVEALS application based on the theory and the simulations described in Sugita (2007a). Such evaluation is an essential step for credible application of the REVEALS model. Unfortunately, no other evaluation studies*

following the strategy of Hellman et al., 2008a have been published so far for other regions of the world."

11. Theuerkauf et al. also write: "*Therefore, in situations where* ***regional vegetation is expected to be patchy****, approaches that do not rely on* ***homogeneity*** *are preferable to REVEALS. For* ***a single site****, multiple scenario approaches allow the detection of vegetation mosaics (Fyfe 2006; Bunting et al. 2008).*" . "Patchy" is not the same as "non homogenous" (see e.g., Hellman et al., 2009a in Rev. Pal. Pal.) and above. The regional vegetation can be patchy for a REVEALS application as long as the patchiness is homogenous, see also point 10 above.
12. **All the points above imply that the authors of the discussed paper (Schmid et al.) MUST clarify how their calculate the "pollen source area" of each site (lake or bog, large or small), what the definition of that source area is, and what it can be used for when it is calculated for a small site, given that it is not the same as the RSAP and does not necessarily define the size of the area for which the REVEALS reconstruction of plant cover is valid.**

Reply

As outlined above, we will **adapt our terminology** and call the parameter calculated by us "80% pollen source area". We define it as the area from which the median relative influx of all taxa is 80%. This is calculated by employing the lake deposition model in Theuerkauf et al.'s REVEALSinR. Starting from zmax the deposited pollen is calculated per taxon. This is assumed to be the total pollen each taxon deposits. This is of course not the reality as pollen can originate from even much further and fluvial inputs into lakes are inevitable as well. But this is an assumption that REVEALS makes as well. In a step-wise process the radius around the basin is increased and the deposited pollen relative to the total influx at zmax calculated for each taxon. We define our 80% pollen source radius as the radius where the median of the relative influx of all taxa reaches 80%. The aim of this calculation is mainly to give an idea of the scale of source area to users not familiar with pollen data. It emphasizes the regional character of lacustrine pollen data and showcases how lake size influences this source area. **We will include this expanded explanation in the manuscript.**

Selection of RPP dataset and RPP values

Original comment

1. The RPP dataset used is the one published by Wieczorek and Herzschuh (2020). The RPP used in Schmid et al (this paper) are mean RPPs based on 1 to n original RPP values, **they are NOT original values**.
2. The Wieczorek and Herzschuh (2020) (WH) dataset does not include original RPP values from the southern hemisphere and doesn't use RPPs published since 2020 in China, Europe, and subtropical/tropical regions as well as Australia. As far as I can see the WH dataset uses only the original values in Commerford et al. (2013) for N America, but not the values from Calcote and others (?).
3. Both points MUST be clarified. As it stands now it looks like a) there are no original RPP values from the southern hemisphere/sub-tropical and tropical regions and b) northern hemisphere RPP values are used for the southern hemisphere and when the SH taxa do not exist in NH the RPP is put to 1. Moreover, Tables A1 and A2 may give the impression to the reader that all these taxa have original RPP values in all continents. **It is VERY CONFUSING! CLARIFY. Do not call the values in Table A1 "Original RPP", <u>these are means of original RPPs AS SELECTED AND CALCULATED BY WH!</u> And provide the Tables A1 and A2 in a different format, with the list of taxa only ONCE in the first column and ascribe the following columns to the**

different continents/regions you have defined. Indicate for each continent whether the RPP value you use is a mean of original values (1-n) from a single continent or several (for instance with an asterisk for the mean value used and indicate with e.g. a cross the continents in which those values are used although there are no original values in those continents. Also indicate what RPP value used is based on a single original RPP value! It would also be useful if the taxa within a family for which a RPP value exists are named, for instance Thymelaceae (only one value and it is for *Stellara* (China), and Orobanchaceae, only one value for *Rhinanthus* type (Europe), etc. This will make the RPP dataset much more transparent, the reader will have the direct information of whether the RPP value is robust for the continent in question or not, without having to go back to WH (2020) and the ESM in there. You could also indicate for the taxa you have put RPP=1 in case there is an original value published since WH (2020) that can be used as an alternative to 1 or your "optimized values", for instance for Alchornea, Melastomataceae, Podocarpus etc (e.g., Gaillard et al., 2021). NOTE: correct the spelling errors of the plant taxa names!

Finally, the points mentioned on the first page of this comment related to other existing continental REVEALS reconstructions and their use could be included the introduction of the paper (or the Discussion). I.e. better describe the difference between this "Global" REVEALS reconstruction and the existing continental REVEALS reconstructions.

Reply

We thank you for making us aware of this confusion. We used "original" here to describe the synthesis values and distinguish them from values that we tried to optimize. **We will change the name for these values to "WH synthesis values".** The synthesis by Wieczorek and Herzschuh does indeed take the 1996 publication by Calcote into account.

Concerning syntheses from reconstructions following Wieczorek and Herzschuh (2020), the synthesis used in Githumbi et al. (2021) was finalized in 2019, before the publication of Wieczorek and Herzschuh, and the RPP studies used overlap with the ones used in Wieczorek and Herzschuh. A set of RPP values in southern France by Mazier was not used by WH, but is cited as "unpublished" in Githumbi et al. (2021) so we were unable to acquire these values or a description of the study. The preprint of Dawson et al.'s reconstruction unfortunately only became available after submission of this manuscript. The authors detail the use of the synthesis by Wieczorek and Herzschuh and the addition of RPP values for *Ambrosia* and *Tsuga* from a previous synthesis. **We will look into the original publications for these values and include them as long as they fill the requirements** for RPP studies as stated in Wieczorek and Herzschuh. We were also made aware of some new **RPP estimates for China and Siberia, which we will include in our synthesis**. The **formatting of our RPP table will also be adjusted** to improve its usability.

Additionally, we will extend our introduction and discussion to further include existing continental scale reconstructions and compare them to our product. As we perceive a high uncertainty for reconstructions in the southern hemisphere, due to a lack of RPP values, **we decide to exclude reconstructions from these records from the data set.**

Detailed Comments

Abstract

adjust after having considered all major comments above. Clarify how the REVEALS dataset of plant-cover reconstructions for single sites of any type and size should be used! Clarify the definition of your “relative pollen source area” that I would rather call “characteristic pollen source area” or simply “pollen source area”. See above.

Lines Comment

Introduction

26 akin ??

- We will change this wording to “not unlike”.

41 “real”, perhaps “actual vegetation” is better4

- We will implement this.

47-49 “By accounting for ….. REVEALS models quantitative vegetation cover in relevant pollen source areas ….” WRONG! Correct

63 “Yet, only Serge et al. …use the opportunity for extensive validation…” WRONG! See Pirzamanbein et al. (2014) for Europe: Pirzamanbein, B., Lindström, J., Poska, A., Sugita, S., Trondman, A. K., Fyfe, R., Mazier, F., Nielsen, A.B., Kaplan, J.O., Bjune, A.E., Birks, H.J.B., Giesecke, T., Kangur, M., Latałowa, M., Marquer, L., Smith, B., and Gaillard, M.J. (2014). “Creating spatially continuous maps of past land cover from point 1780 estimates: A new statistical approach applied to pollen data.” Ecological Complexity 20: 127–141. https://doi.org/10.1016/j.ecocom.2014.09.005

- We will add this reference here as well.

64 “No site-wise validations …. exist….” What do you mean? What about the the validations by Hellman et al., 2008a and b, and Sugita et al., 2010, and others?

- Here we refer to site-wise in the sense of a large-scale reconstructions that still aims to validate at a site-level as opposed to a gridded level, which is what we were aiming to do here for reconstructed forest cover from large basins.

Mention somewhere in the Introduction the available syntheses of RPP without forgetting the latest RPP synthesis for Europe published in Githumbi et al. (2022a) and the new REVEALS reconstruction for northern America: Dawson, A., Williams, J. W., Gaillard, M.-J., Goring, S. J., Pirzamanbein, B., Lindstrom, J., Anderson, R. S., Brunelle, A., Foster, D., Gajewski, K., Gavin, D. G., Lacourse, T., Minckley, T. A., Oswald, W., Shuman, B., and Whitlock, C. (2024). “Holocene land cover change in North America: continental 1410 trends, regional drivers, and implications for vegetation-atmosphere feedbacks.” Climate of the Past 1411 Discussion [preprint]. https://doi.org/10.5194/cp-2024-6 , in review, 2024.

Reply

Even though the reconstruction by Githumbi et al. was published in 2022, the RPP synthesis was completed in 2018 prior to Wieczorek and Herzschuh (2020). The same studies were considered in Githumbi et al. and Wieczorek and Herzschuh with the exception of one unpublished study concerning RPP values in southern France by Mazier. We were not able to acquire the values from this study. Githumbi et al. provide more RPP values because a combination of taxa was not done as in Wieczorek and Herzschuh.

The preprint by Dawson et al. (2024) was unfortunately only available after our submission. We did find that the authors used RPP values as synthesized by Wieczorek and Herzschuh for Northern America. RPP values for two additional taxa were added and as stated above we will look at the original publications for these values to see if they fulfill the prerequisites to be added to the synthesis previously prepared by Wieczorek and Herzschuh.

Methods

Figure 1 Explain in the Figure caption what the different colours of dots mean, I guess lakes versus bogs

- All of the points are slightly transparent to see where many records are leading to a higher density of records. We will add an explanation to the figure caption.

86-87 page 4 last lines until ca line 95 page 5
Explain the REVEALS model better and correctly OR simply refer to Sugita (2007a).

- We feel that a concise description of the model is adequate and cite Sugita in line 85. We will add an additional reference to Githumbi et al. 2022 for an additional description of the REVEALS model.

97 “using peatland records for reconstructions is, therefore, appropriate.” NOT CORRECT. You MUST clarify that only pollen records from small bogs can be used if the mean REVEALS estimates from SEVERAL single small bogs is used, and even better, if the mean REVEALS estimates are from a mix of SEVERAL small bogs and small LAKES. Etc…. see major issues above

- “using peatland records for reconstructions is, therefore, appropriate when spatially averaged…”

8 (12)
Table 2 Several of these are not parameters but models, methods or function …..

- We will change the table title to “model settings”.

Figure 3 Specify that the “available” RPP values are not necessarily original values obtained in these continents, but can be values obtained in other continents, right?

- We will clarify this in the figure caption and add additional information in the figure to highlight the fraction of continental values.

110 Modifications in REVEALSinR:
a. What are these modifications? Are they modifications compared to REVEALSinR published in Theuerkauf et al (2016) or modifications compared to the REVEALS program by Sugita? Or anything else?

- These are modifications compared to Theuerkauf et al.’s REVEALSinR. We will clarify this in the text.

b. You did not calculate the “relevant source area of pollen” (RSAP) but something else that you define as “the radius in which etc…..total nflux (…..).” RSAP is something else, see my major comments above. Moreover the definition you provide is badly written, use instead the wording for the definition given in Theuerkauf et al. (2016)

- We will adjust the naming as described above and edit the description of the definition to contain more detail.

117-127 This validation is problematic as it uses the REVEALS estimates for individual sites which implies that the reconstructions using pollen records from small sites (lakes or bogs” will be biased compared to the REVEALS estimates obtained with pollen records from large sites. If you keep this “validation”, you MUST clarify that the REVEALS estimates for the small sites can be strongly biased and therefore the correlation with the modern vegetation might be less good than if you would use the mean

REVEALS estimates from several sites within a given area size (e.g., grid cells of 1 degree, or vegetation regions, biomes, or continents).

- We will add an additional validation using spatially gridded forest cover to check for this potential bias and discuss it in the manuscript (also see Figures 1-3 above).

134 I do not understand this equation, it doesn't make sense to me. This perhaps because it is not clear what you mean with "reconstructed tree cover", and "corrected tree cover". It is clear what "unvegetated" cover is, and it is clear that you have to adjust the modern vegetation cover by using the sum of open vegetated cover as 100% or (1) (i.e. total open cover – unvegetated cover = 1). Is your "reconstructed cover" the total open cover including the unvegetated cover? The use of "reconstructed" here is confusing

- Reconstructed tree cover pertains to the tree cover reconstructed from a pollen product. In our manuscript this includes the original pollen counts, REVEALS reconstructions and optimized REVEALS reconstructions. It is created by summing the percentage of arboreal taxa. Because of the closed compositional nature of pollen records, there is no way to reconstruct unvegetated areas with pollen counts. The value we get can be defined as the percentage of forested area in the vegetated source area around the basin. The forest cover available in remote sensing products is differently defined as the percentage of forested area in the total source area around the basin, which includes unvegetated areas. In order to correct for this within the validation we make use of land cover maps and extract the percentage of unvegetated area in the source area around the basin (Equation 2). This way we are able to convert the reconstructed forest cover to a value which also represents the percentage of forested area in the total source area around the basin and enables a comparison between remote sensing forest cover and corrected, reconstructed forest cover.

General comment for Methods: I do not understand from this description what is the time resolution of the reconstructions, from the Figure 8 it looks to be 1000 years. In this case, this should also be mentioned as a difference in comparison with the continental PAGES LandCover6k that use 500 years resolution up to recent times, and 3 shorter time windows, 350, 250 and ca 100 years between 0.7 k BP up to "present" (see e.g. Trondman et al., 2015).

- The temporal resolution of the reconstruction is that of the original records. For the gridded data set users can choose their own temporal resolution. We will supplement a script to the manuscript that allows this and will expand on the use of the data set in the data usability section of the manuscript.

Data Summary

3.1 Pollen source area Adjust according to my major comments above

- We will change the name to "80% pollen source area" as described above.

3.2 Comparison of original and optimized values Do not use the term "original" for the RPP values you are using but rather "WH mean RPP values" or something similar. The values you are using are not "original values from specific studies unless there is only ONE value that you are using. See my major comment re Tables A1 and A2

- We will change the descriptor to "WH synthesis values".

Figure 4 Map indicating the size of relevant pollen source areas: CORRECT! It is not RSAP!

- We will change the name to "80% pollen source area" as described above.

165-169 "The highest and lowest absolute change respectively occurred for Quercus (4.08) and

Fabaceae (0.09) in Africa, etc….” What do you mean? Is it a +/- change or only + change, specify! I see that it is often a + change. I would write: “The highest respectively lowest absolute change (highest/lower) occurred for Quercus (+4.08)/Fabaceae (-0.09) in Africa. If this is not what you meant, CLARIFY!

- We will add signs to the change values to clarify the direction of change here.

175-197 The comparison presented in Figure 7 is fine as you have calculated average REVEALS-estimated cover for whole continents, which is OK even if you used pollen records from small sites. See my major comments above. My question is: did you calculate errors for the average REVEALS estimates using the errors produced by REVEALSinR from each individual pollen record?

- We did not calculate errors for this figure and only show mean values. Errors would have to be calculated using the delta method, which will be appended in our rasterization script.

199-209 Similarly, Figures 8 and 9 present average forest cover using REVEALS estimates from pollen records available within 10 degrees grid cells, which means that most grid cells are represented by REVEALS estimates using several pollen records. As these data are also made accessible, it would be useful for the user if you added a file that provides the identity code of the grid cells for which the “average” REVEALS estimate is based on the reconstruction from a single pollen record from one-several large bog(2), or 1-2 small bog(2), or 1-2 small lakes, or 1 small bog + 1 small lake. See example in Githumbi et al. (2022a).

- We will add this classification in this figure and include it in the script for rasterization to be used by the user.

3.5 validation It is not correct to validate the REVEALS model with modern vegetation data SITE BY SITE, given that a REVEALS reconstruction using a pollen record from ONE large bog or ONE small site (bog or lake) will in most cases be biased. **A proper revision of this paper should/MUST use the 10 degree grid cell reconstructions to validate these new REVEALS reconstructions (using WH RPP dataset or optimized RPP), and use the cover of modern vegetation within those same grid cells for comparison. Even the SLOO validation should be redone using 10 degree grid cells as the basis for the validation.**

- We will redo the validation using rasterized data as already prepared in figure 3 above.

251-258 The major difference between N hemispheric vegetation and sub tropical-tropical vegetation is that: in northern and temperate (mediterranean) regions a majority of the tree species are wind pollinated and produce large quantities of pollen per unit area, while pollen of herbaceous plants use to be insect pollinated or both wind and insect pollinated and produce less quantities of pollen per unit area, which implies that trees often are overrepresented by pollen compared with herbs; in (sub) tropical regions it is the inverse, many trees are insect pollinated and often produce small quantities of pollen which implies that herbs may be overrepresented by pollen compared to trees. The latter is well illustrated by Figure 10 pollen % versus remote sensed plant cover.

In this section you MUST clarify that you have not used the RPP values that have been obtained from modern pollen-vegetation datasets in (sub) tropical regions and are available today in published articles (China, Africa, southern America) and provide
example references (you do not need to do a literature search given that you do not use them). It’s however important that you inform the reader that such values exist. For instance, in Gaillard et al. (2021) the obtained RPP in Cameroon for 13 taxa are compared with values obtained for these taxa in Africa and China, which already provide

a significant number of existing values. Another useful paper is that by Wan et al. (2020): Wan, Q., Zhang, Y., Huang, K., Sun, Q., Zhang, X., Gaillard, M.-J., Xu, Q., Li, F. and Zheng, Z., 2020, Evaluating quantitative pollen representation of vegetation in the tropics: A case study on the Hainan Island, tropical China. Ecological Indicators, 114, article: 106297, 10.1016/j.ecolind.2020.106297.

- We decided to exclude the southern hemisphere from this reconstruction as missing RPP and high fraction of insect pollination make our reconstruction too unreliable here.

Dataset applications and limitations and Conclusions

Adjust these two sections according to the major comments explained in the first part of this review in addressing all the issues implied by your dataset, in particular the REVEALS estimates for single sites.

285-286 "…with previous REVEALS applications and show an increase ….until roughly 4 ka BP (references). **This is not correct, the REVEALS reconstructions mentioned show an increase of forest cover/respectively a decrease in openland cover until around 6 ka BP.** The best reference for this is Strandberg et al. (2023) in Clim of the Past and Figure 1 therein that is based on the REVEALS reconstruction from Githumbi et al. (2022a, in ESSD).

- We will correct this.

293-294 The deglacial forest conundrium (or Holocene temperature conundrium (HTC)) is also discussed in Strandberg et al. (2022, in QSR).

- We will add this reference.

References

387-389 replace this reference by/ or add : Dallmeyer et al. (2024) in Clim Past Discussion: Dawson, A., Williams, J. W., Gaillard, M.-J., Goring, S. J., Pirzamanbein, B., Lindstrom, J., Anderson, R. S., Brunelle, A., Foster, D., Gajewski, K., Gavin, D. G., Lacourse, T., Minckley, T. A., Oswald, W., Shuman, B., and Whitlock, C. (2024). "Holocene land cover change in North America: continental trends, regional drivers, and implications for vegetation-atmosphere feedbacks." Climate of the Past Discussion [preprint]. https://doi.org/10.5194/cp-2024-6 , in review, 2024

- We will reference Dawson et al.'s (2024) manuscript now as it was not available at the time of submission.

409-413 replace the Githumbi et al. 2021 in Clim Past Discussion by Githumbi et al. (2022): Githumbi, E., Fyfe, R., Gaillard, M.-J., Trondman, A.-K., Mazier, F., Nielsen, A.-B., Poska, A., Sugita, S., Woodbridge, J., Azuara, J., Feurdean, A., Grindean, R., Lebreton, V., Marquer, L., Nebout - Combourieu, N., Stančikaitė, M., Tanţău, I., Tonkov, S., Shumilovskikh, L., and LandClimII data contributors (2022a). "European pollen-based REVEALS land-cover reconstructions for the Holocene: methodology, mapping and potentials." Earth System Science Data 14: 1581–1619. https://doi.org/10.5194/essd-14-1581- 2022

- We will correct this citation.

Do remember to also refer to Trondman et al. (2016) (see my major comment on the application of REVEALS using pollen records from small sites): Trondman, A.-K., Gaillard, M.-J., Sugita, S., Björkman, L., Greisman,
A., Hultberg, T., Lagerås, P., and Lindbladh, M. (2016). "Are pollen records from small sites appropriate for REVEALS model-based quantitative reconstructions of past regional vegetation? An empirical test in southern Sweden." Vegetation History and Archaeobotany 25: 131–151. https://doi.org/10.1007/s00334-015-0536-9

- We will add this reference.