

Dear editor,

We thank you and the referee for the comments to improve the manuscript. As it appeared to us that the main remaining concern for accepting the manuscript is its clarity, we made an effort to refining its structure and explanations (point-by-point response is below) and asked, as suggested by the editor, another colleague, i.e., Valerie Daux, for a pre-review. Although Valerie's work is mostly on the data-side of tree-ring research, she is well aware of the strengths and weaknesses of land surface modelling. We asked Valerie to comment on the manuscript as if she was a referee. Valerie appreciated the nuanced usage of both data and models in the study and considered the proposed benchmarks as possible ways to make some progress in the field. She made several suggestions and recommendations to further improve the flow and clarity of the text.

We feel confident that the flow and clarity of the manuscript has improved and that the manuscript can give new ideas to the land surface modelling community to constrain their models with a long-term benchmark, i.e., tree-ring width.

Kind regards,

Jina Jeong on behalf of the author team

Referee

Major specific comments:

(1) Line 206 "virtual forest"

No definitions for the "virtual forest". As authors mentioned in the line 229-230, the proposed method largely relies on the concept of "virtual forest". So, missing its definition is ridiculous.

We added further descriptions about virtual trees in L175-185. Furthermore we realized that the separated numbering for virtual trees and benchmarks which make use of virtual trees was causing a discontinuity in the text flow possibly resulting in confusion. Accordingly, those parts were combined into one section (Section 2.3).

(2) Line 216-220 "Calendar year aligned virtual forest"

I strongly doubted this can be a metric to be compared with outputs of LSMs, because it should have systematic and strong bias as follows.

At the early stage of year, it has low values, because sampled trees (old and big trees) are in its young stages. During the middle period of the data, new trees (at young stage) add to the average calculation, and these trees function as a burden to increase the metric value. During the late period of the data, no tree enters to the average calculation anymore, so the metric value should show intense increasing trend.

The referee is right. Because of this issue during the early stage, the first decades were not used in the analysis which was described in the section for benchmarks (Section 2.3 in the previous revision) but not in the section for virtual trees (Section 2.2 in the previous revision). As mentioned above, we combined descriptions for the virtual trees and benchmark to overcome such discontinuities (Section 2.3).

(3) Lines 141-142

This sentence concludes the paragraph. But, I cannot understand why this conclusion comes out.

We rewrote this sentence for increased readability. (L114-115)

(4) Lines 144-153

Is it possible to rewrite this paragraph so that readers, who are not familiar with dendrochronology and LSMs, can easily understand? Honestly, I still do not understand the point of this paragraph.

More information was added in this part. (L118-125)

(5) Line 241

Here, the “Size related diameter growth” is identical with the “Age-aligned TRWs” in line 212? Inexplicit rephrasing causes confusion, and hence should be avoided.

“Size related diameter growth” signifies that the tree diameter increment tends to decrease as the size of the tree increases, which in turn, forms decreasing tree-ring trends as Fig. 3a and Fig. 4a. “Age-aligned TRWs” describes the alignment of tree-ring widths observation (the difference between Fig. 3 b and c). This inquiry and misunderstanding from the referee may find its origin in the description of virtual trees, therefore, we improved the explanatory part of virtual trees (e.g., L175-185 and L193-196).

(6) Lines 253-274

I cannot follow logics here.

We added further descriptions for better understanding (L205 and L211-215).

Minor specific comments:

(1) Lines 200-202

Citing figure 4 in these sentences does not make sense.

Figure 3 (figure 4 in the previous revision) shows different virtual trees but also shows how the ITRDB dataset is usually organized. We think this figure can help readers who are not used to tree-ring datasets understand the data. In this revision, as mentioned above, we tried to improve the description of virtual trees (Section 2.3).

(2) Figure 1

I think this figure is needless.

This figure describes the motivation of the study. We agree this is not necessary for the content, so we moved it to the supplementary materials.

(3) Figure 4a

What the vertical axis means? Tree-ring width of the outmost stratum?

As it is now written in the figure, it means tree-ring width for both observation and simulations.

(4) Figure 4c

According to the figure caption, lines on this figure should be identical to those of the figure 4b; Figure 4b and 4c only differ in the alignment on the x-axis. But, shape of the black-dottedlines differ between these figures.

The confusion occurred since black dotted lines in figure 3 (figure 4 in the previous revision) were referred to as a ‘virtual tree’ without specifying which virtual trees are. We improved the caption of the figure.

(5) Line 676

A typo exists. Location of the period would be immediately after "(c)".

Thanks for noticing. This typo was corrected.

(6) lines 677-678

Is this sentence an explanation for the figure 5b? But, figure 5b shows extraction of major lines on the figure 5a, not the root-mean-square error.

The specifications for corresponding subfigures were added.

Editor

1) One obstacle to the intelligibility may be the enumerations in sections 2.1-2.3 (and beyond), all of which have 3-5 bullets that partly relate but are not fully consistent, which also raised questions by reviewer 3. Condensing and/or restructuring section 2 would certainly improve comprehensibility.

We agree with the editor's comment about complexity coming from different numbers of bullets, therefore, the content for virtual trees and benchmarks were combined (Section 2.3). This reduced the number of bullet lists. We hope this improved readability.

The new Fig. 2 connects these elements to some extent but foremost serves as a visual TOC. An option may be to extend Fig. 3 with the corresponding virtual trees, metrics, processing, etc. if feasible without overloading.

Fig. 1 (Fig. 2 in the previous revision) was extended to cover virtual trees.

In addition, section 2.3 (iv) contains two metrics, amplitude and timing, which further complicates connecting the descriptions with display items and results. Please consider these as exemplary notes and suggestions.

Lines emphasizing the difference of metrics were added in L351 and L472-473.

2) Due to the importance of the virtual tree concept in the study, introducing a separate sub-section would aid in highlighting this.

We added further descriptions about virtual trees in L175-185. Furthermore we realized that the separated numbering for virtual trees and benchmarks which make use of virtual trees was causing a discontinuity in the text flow possibly resulting in confusion. Accordingly, those parts were combined into one section (Section 2.3).

3) As this study should be considered a proof of concept and presents comprehensive conceptual elaborations, mentioning this in the abstract would aid in guiding readers' expectations. Also mentioning the number of sites used for testing would be helpful in this respect.

This context was added to the abstract (L7-8).

4) Legends would improve accessibility of figures. Also check use of "dotted" or "dashed" when describing line types.

Legends were refined and added to the appropriate figures, i.e., Fig 3,4,5,6 and 7.

Non-public comments to the Author:

I also encourage the authors to have the revised manuscript critically pre-reviewed by colleagues not involved in the research.

Following the above suggestion, we asked for a pre-review, and the comments from the pre-review were addressed before the submission (see also the cover letter itself).