

## ***Interactive comment on “Harmonizing plant functional type distributions for evaluating Earth System Models” by Anne Dallmeyer et al.***

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Received and published: 6 November 2018

R: I think that the paper of Dallmeyer et al. is a serious work and presents interesting findings in terms of method and results. The choice of Climate of the Past is, for me, appropriate: even if this paper mainly focus on vegetation models, it is also based on general circulation models. I think this paper is clear, well written and can be published in Climate of the Past with minor changes, which are listed below:

R: - abstract: must be reworked, it should be more informative on the methods, the results and more precise (method, key results, conclusions) : how many models are used, which is the principec of the method . . .

Our response: Thank you very much for the helpful comment, we revised the abstract

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including more information on the method and its application in our study.

R: - introduction: this point concerns the originality of this paper, you need to better justified the objective and the questions of your paper given that at least two biomisation methods exist and work well (Prentice et al., 1992, 2011). The new biomisation method must be more clearly defined?

Our response: We agree with the Referee that the aim of providing a new method was not stressed enough. We now describe the problem with the classical method and the advantage of the new method more precisely: "... Using this classical method of biomisation, fundamental palaeo-vegetation analysis can be undertaken (e.g. Jolly et al., 1998; Harrison et al., 2003; Wohlfahrt et al., 2008; Harrison et al., 2016, Dallmeyer et al., 2017) without requiring an explicit calculated vegetation distribution by the Earth System Models. On the other hand this also means that existing simulated plant functional type distributions calculated by the DGVMs being dynamically coupled in these models are neglected, since only the simulated climate pattern is taken into account. The biomisation via diagnostic biome models did not include any information on the original PFT-distribution simulated by the Earth System Models. As the DGVMs are generally more complex than the biome models and include more relevant processes, valuable information included in the PFT-distribution gets lost in the classical biomisation by the biome models. A more appropriate way of biomisation would be to use directly the PFT-distributions calculated by the DGVMs." and: "To harmonize (palaeo)-vegetation distributions simulated by dynamic vegetation models and thereby facilitate the evaluation of Earth System Models (ESMs) and the comparison of model results and biome reconstructions, we developed a biomisation technique that is based on the PFT-distributions simulated by the DGVMs and few input variables and simple differentiation rules."

R: What is “natural” PFTS (line 36)?

Our response: we included '(non-anthropogenic)' as explanation for the natural.

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R: Line 44, the ref Prentice et al., (1996) is needed.

Our response: This reference is included a line before.

Methods R: line 91: what is mean growing degree days? GDD0 or 5? Please define it.

Our response: We actually need both, GDD0 and GDD5. We add this.

R: Could you also define the “multi-year mean PFT cover fractions”.

Our response: We further define it: “... multi-year mean PFT cover fractions (e.g. averaged over 100 years) are required.”

R: Why don't you use the alpha parameter classically used in Prentice et al (1992, 1996).

Our response: The wetness is usually considered in the dynamic global vegetation models, i.e. in the cover fractions of the PFTs. In BIOME1 the alpha is needed e.g. to distinguish steppe and desert, but this differentiation is already done by the dynamic global vegetation models. A desert is a region in which only a small grid-cell fraction is covered by vegetation, etc. We only need the temperature limits for distinguishing the climatic zones (e.g. tropical vs. temperate vs. boreal).

R: Line 109: GDD0 exceeds 800°C or to the biome 'tundra', if GDD0 is below 800°C: could you explain the choice of these values?

Our response: we took these values from the BIOME4 model (i.e. the differentiation of steppe tundra and temperate grassland in BIOME4), we add the reference.

R: -simulations: line 121 “Simulations from nearly all state-of-the-art global dynamic vegetation models”: the exact number of models is needed here as the name of the models.

Our response: We include the number and names of the models in this introductory sentence: Six different models could be considered (i.e. JSBACH, TRIFFID, OR-

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CHIDEE, SEIB, LPJ and VECODE).

R: “Overall, eight simulations for the pre-industrial climate (PI) and vegetation, four for mid-Holocene (6k) conditions and five for Last Glacial Maximum (LGM) conditions have been used (Tab.4)”: if I look at tab4, I find 6 simulations for PI, 3 for 6 ka, and 4 for LGM: please check; the format of tab 4 is not easy to read: correct it.

Our response: Thank you very much for this hint, this is indeed confusing. The original table includes the simulation names according to the references. We now change this column to 'period' to be less confusing and add the name of the simulations (where needed, i.e. Klockmann et al. Simulation) to the references. Please notice that Tab.4 is now Tab.3.

R: Line 140: what is CRUNCEP?

Our response: We further explain this: ...that is a combination of observations (CRU data) and reanalysis data (NCEP).

R: preparing the reference datasets: OK for the 6 ka and LGM but I have a problem with the comparison for the PI Period. The comparison with the Pre-industrial changes is an important point to validate the results. However, the models uses the pre-industrial period as a baseline whereas the pollen-inferred biomes use the late 20th century (modern pollen data used for the 0 ka in biome 6000 have been collected from 1960 to present day, so they don't correspond to preindustrial period). On the same way, in the RF99 dataset, Ramankutty and Foley used a global representation of permanent croplands in 1992, which not represent the PI period. This points of the discussion must be added and discussed in depth (CO2 bias and human impact).

Our response: We are aware of the temporal differences between the reference datasets and the model simulations and agree to the referee that this has to be clarified. We add the following information to the text: "Both vegetation datasets are derived for the modern time-slice not exactly corresponding to the pre-industrial period (around

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1850 AD) simulated in the models. While the ice-sheet, the topography and the orbital conditions used for the pre-industrial control simulations are prescribed from modern conditions, greenhouse gases are set to pre-industrial values in the models. These differences in e.g. atmospheric CO<sub>2</sub>-concentration between the reference datasets and the simulations may lead to small discrepancies in the model. In addition, the references may be disturbed by anthropogenic influences.“

R: -results: -lines 350-3522: you forget to discuss the increase of the temperate forest in Europe at 6 ka.

Our response: This is correct, but here we only discuss the pronounced changes. We did not change this.

discussion R: caveats in the method: line 401: the biome warm mixed forest is not only subtropical but also appears in Europe: please correct.

Our response: we now write: "warm-temperate forest (e.g. subtropical forest)“

R: Line 432: could you define the “anthropogenic plant functional types”?

Our response: we added "(i.e. land use)“ to the text.

R: line 446: you state that the procedure of reconstructing paleovegetation often include modern analogue technique. I don't agree with that. The MAT is used to reconstruct the climate, not the biomes. The biome procedure using pollen follows the biomisation defined by prentice et al 1996, and peyron et al 1998 ...using a pollen-taxa –PFT assignment and a PFT-biome assignment which is done on modern samples (0 ka), and fossil samples (6 and LGM) independently. Please correct the text.

Our response: We agree that the term 'modern analogue' is inappropriate in this context. By this we meant that the transfer matrices from taxa into PFTs and from PFTs in Biomes were compiled on the basis of the recent vegetation. And these matrices do not have to be constant in time, i.e. they may not be applicable for glacial vegetation. Furthermore, the classification of the biomes was made on the basis of recent vege-

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tation, but this classification does not have to correspond to the glacial classification, there were possibly other biomes that remain unconsidered. We changed the text to: Likewise, the matrices for the assignment of taxa into PFTs and from PFTs into Biomes have been constructed on the basis of the recent vegetation. These matrices do not have to be constant in time, i.e. they may not be applicable for glacial vegetation. Furthermore, the classification of the biomes itself corresponds to the modern vegetation and does not necessarily have to reflect the palaeo-vegetation. There might be other biomes in glacial climates that remain unconsidered.

R: biases in the PI ..., line 455: the classical method of biomising.. a ref is needed here.

Our response: We agree and now write: "The classical method of biomising climate states via biome models (here BIOME1 by Prentice et al., 1992)..."

R: Line 468: could you give more details on the sensitivity study performed by Dallmeyer et al 2017?

Our response: We agree to provide more details here. We now write: "A sensitivity study is performed following Dallmeyer et al. (2017) to relate differences in the biome distributions to precipitation or temperature deviations in the background climate (Fig.12). For this purpose, we successively replace the temperature or the precipitation in the CRU-TS4 forcing file for the BIOME1 model with the respective pre-industrial temperature or precipitation distributions simulated by the models. Afterwards, we compare the differences between the calculated biome distributions“

R: line 479: NPP ratios, not the acronym.

Our response: done.

R: Line 483: what do you mean by low score? Its not clear on the fig.

Our response: This is indeed misleading. We clarify this with: For the PFT-biomisation of CLIM-LPJ, k is basically reduced by an overestimation of boreal forest...

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Figures R: too many figures! I strongly recommend to group the figures 2 and 3, and also the figures 9 and 11 ; the figures 4 and 8 can be moved to suppl. Material (not discussed in depth and not very useful).

Our response: We agree that we provide many figures, but we decided against grouping them so that we do not have to further reduce the size of the figures which are already quite small. Figure 4 is essential for the comparison between the classical and the new method, we keep both figures in the main text to facilitate the readability and comparability. Instead we move Fig 15 and the discussion of the comparison of the FPC-method and the PFT-method to the Appendix. We furthermore reduce the numbers of Tables.

References R: please check carefully your references, some are missing (Dallmeyer et al., 2017; Tian et al., 2017...) or not homogenized.

Our response: We homogenized the references and also add the missing references.

other points: R: in the text, you often write "pollen-based reconstructions" or "reconstructions"; I don't like this terminology because the pollen also is used to reconstruct climate or other : could you replace in the text by pollen-based (or inferred) biomes which is more precise and used.

Our response: We agree, this was not precise. We change the "reconstructions" to "pollen-based biome reconstruction" whenever it is relevant.

R: homogenize in the text: pi, PI, Pi -figures:

Our response: Thank you very much for carefully looking through the manuscript. We now use PI.

R: fig.1: Could you replace on the fig. "climate limits" by "bioclimatic limitation" and refer in the caption to tab.1 (climate limits) and tab 3 (Min cov. and Climate limits); the 4 simulated PFTs doesn't correspond to the text (p3: desert, forest, wood, grass and total vegetation): please check!

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Our response: We adapt the figure according to the referees suggestion and change the PFT groups in the figure and the text and refer to Tab.2 including the detailed information.

R: fig.2 and others: could you change the color of grass? The green one is not very clear and can be confused with the temperate forest, orange will be better and commonly accepted by the biomisation community. This fig. must be group with fig.3.

Our response: We choose this colour set to be in line with our other publications. We do not change it. The Panel figures are quite small, to avoid a further reduction of the size we do not group Fig. 2 and 3.

R: fig.12: Not clear: what is the range of the climate factor? Could you explain better how they are calculated and not just refer to Dallmeyer et al. 2017?

Our response: The figure just shows, which climate input field leads to the differences in the biome distribution. Thus, the climate factors do not really have a range. We further explain the method in the text (see comment above) and also in the figure caption: "...The factors were calculated by performing a sensitivity test with the BIOME1 model following Dallmeyer et al. (2017) by successively replacing the temperature or the precipitation in the CRU-TS4.0 forcing file for BIOME1 with the respective data from the different PI simulations."

R: fig.15: even if it's explained in the text, its strange to see the biome savanna in Europe and Medit. Area (may be explain better in the fig. Caption)

Our response: We moved this comparison to the Appendix and also explain in the caption that the biome distribution inferred by Zhu includes temperate savanna. We write: "...Please notice that the FPC-method distinguishes temperate parkland, sclerophyll woodland and boreal parkland that all have been assigned in the mega-biome savanna, but savanna is only defined as tropical savanna in the PFT-method"