Autors response to referee 1

November 7, 2022

We thank reviewer 1 for his/her constructive comments on our technical note. We provide a detailed response in the text below, where the R1 comments are marked in blue, our response in black. Changes in the revised manuscript are in magenta for referee 1 and in blue for referee 2.

Comment: In their paper "Accelerated photosynthesis routine in LPJmL4" the authors show that using a different algorithm in a subroutine of the photosyntheis computation leads to model speed up and higher numerical accuracy of the DGVM LPJmL. I very much agree with the authors that DGVMs need improvements in their numerical methods to decrease their computing time. Therefore, I see the proposed methodology as an important step towards this goal.
Response: We are grateful that the reviewer supports our argument on improving numerical methods by which the computational time and numerical accuracy for key routines that form the core of Dynamic Global Vegetation Models are improved. Given the fact that first versions of DGVMs were published in the late 1990ies and early 2000s, it becomes necessary to revisit the methods of existing core routines from which many other modelled processes in the model depend.

Comment: However, I find that replacing the bisection method with the Newton method to find the root of a continuous function does not suffice for a technical paper. A short technical comment could be appropriate, but quite frankly I believe that this (nonetheless important) improvement of LPJmL should simply be mentioned in the release notes of a new release of LPJmL.
Response: We agree that the extend of the study shown here is comparably small in relation to other model development papers. However, we would like to stress that we use the implementation of the Newton method exemplarily to show and underline the necessity on how mathematical knowledge can be used to revisit and improve existing routines in models that are now continuously developed and applied in, e.g., climate change studies, for nearly two decades. Moreover, we think that these aspects do not receive enough attention in publications of larger model update papers, which serve different objectives.

Comment: I also find that important things are not sufficiently discussed, namely: 1. There are only two citations when mentioning that this representation of photosynthesis is used in the majority of DGVMs. There are also other representations of PS and more citations will underline the point that Farquhar-Collatz is really the most used one.
Response: We thank the reviewer for pointing out that the references are not complete. Reviewer 2 had made a similar remark. We therefore refer to our respective author response. (The additional text in the revised manuscript is in blue.)

2. It should at least be mentioned that the function f suffices all criteria for the Newton-method
Response: The Newton method requires that f is at least three times differentiable and the

first derivative of f at the iteration is not zero. We now explain this in the text (in magenta in the revised manuscript) and the sentence now reads:

The function f is defined for all $\lambda > 0$, as long as $(J_E(\lambda) + J_C(\lambda))^2 \geq 4\theta J_E(\lambda) J_C(\lambda)$. As a composition of at least three times differentiable functions it fulfills the differentiability condition of Newton's method.

The condition $f'(\lambda) \neq 0$ as well as the suitability of a staring value can not be generally ensured. In all our computations convergence was not a problem. To be on the safe side, one can implement a hybrid method that switches to bisection if convergence of the iterates does not occur.

3. Actually also a plot of f would be interesting to see, at least for one particular set of parameters, to let the reader get an impression of how this function looks like.

Response: We thank the reviewer for this helpful remark, as we agree that this additional plot helps to enhance the understanding of the function. We have identified the parameters that define the function f. Since some of these parameters vary with geographic location (average climate conditions) and season we have plotted them for a boreal, temperate and tropical site. All three sites are used as a standard in our model benchmarking. We have plotted f in a new Figure 1 and added the following text:

The parameters in the definition of f vary with the geographic location and season. A plot of f for parameters from different locations (boreal, temperate, and tropical) and at different times can be seen in Figure 1.

4. The Newton-method may fail when the starting value is chosen too far away from the root, it is not discussed whether this could become a problem.

Response: We discussed this comment in the text (see above): The condition $f'(\lambda) \neq 0$ as well as the suitability of a staring value can not be generally ensured. In all our computations convergence was not a problem. To be on the safe side, one can implement a hybrid method that switches to bisection if convergence of the iterates does no occur.

5. Some outputs had much higher changes when the new method was applied. There is no discussion why that could be.

Response: We have stressed that the changes appear larger but are of small dimension due to small absolute values. Since these occur in areas of low productivity for which reliable validation data are difficult to obtain, therefore hard to decide which version yields more reliable results. We also refer to our detailed response in our response to Reviewer 2, where we additionally tested the parameter sensitivity on annual GPP.

Comment: To conclude, I unfortunately cannot recommend this manuscript for publication as I evaluate its impact as too low for a paper in GMD.

Response: We hope that we have provided the required information and additional explanations that the revised manuscript would deserve publication as a technical note in GMD, also with the material added following review 2.