

Review of revision 2: “Impact of changes in climate and CO₂ on the carbon-sequestration potential of vegetation under limited water availability using SEIB-DGVM version 3.02”

General comments

General comments from my original review:

In this manuscript, the authors perform simulations with the dynamic global vegetation model SEIB-DGVM to explore the impact of historical changes in climate and atmospheric CO₂ concentration on potential carbon sequestration in live vegetation. Intriguingly, they look not just at total biomass, but also “aboveground” vs. “belowground” biomass (although those terms are misleading; see below). This allows the authors to examine how plants have shifted their growth strategies over the last century to maintain a competitive edge under environmental change.

The results show that both biomass pools have increased, but with “belowground” increasing more than “aboveground” on a relative basis. Factorial experiments reveal that atmospheric CO₂ increase is unsurprisingly the dominant driver of potential biomass increase in most of the world, but temperature and other factors are more important at latitudes above 60°N. The results also show that “aboveground” and “belowground” responses to environmental change differ along an aridity gradient, as well as from each other.

The authors designed a suite of experiments well-suited to explore how plant individuals and communities have changed their growth strategies to deal with environmental change. However, the manuscript needs substantial rework. Most importantly, while the Introduction briefly mentions previous findings regarding shifts in above- and belowground allocation under environmental change, this should build up to a set of hypotheses that are then tested with the model experiments. It is also unclear why this was submitted to *Geoscientific Model Development*. Perhaps if it were more focused on comparing SEIB-DGVM biomass to observations it would fit as an evaluation paper, but the work performed is much more high-level than that. I thus think it would be more appropriate to move to *Biogeosciences*.

And from my second review:

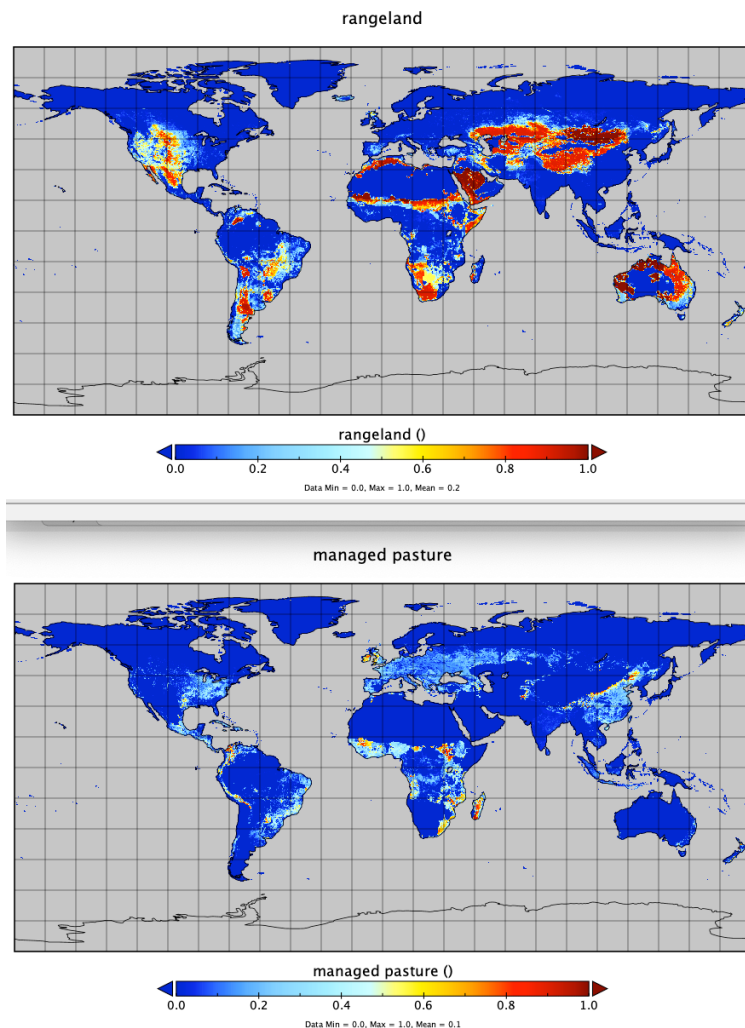
The authors decided not to move journals, which is fine. They have made significant improvements in terms of explaining how water stress theoretically affects allocation, as well as tying their results back to this theory. However, I still have some significant questions about the methodology and confusion about the interpretation of results. As such, I again suggest this manuscript be reconsidered after major revisions.

In the latest (second) revision, the authors have done a good job of responding to my comments. They improved their methods significantly by (a) excluding grid cells that changed aridity classes and (b) refining their pasture-cell exclusion rule. Additionally, they have made great improvements in terms of explaining their analyses. As a result, I suggest this paper be ***published after minor revisions***.

Specific comments

Pasture vs. rangeland

You masked based on the LUH2 “managed pasture” layer, but most grazing land by area is actually *rangeland*—see below for 2010. Please consider the exclusion based on the total pasture+rangeland area. (I’m sorry, I should have caught this in the first revision!) Alternatively, there may be an argument that rangeland doesn’t need to be excluded, as might be considered less intensely grazed. If you want to go that route, mention it in the text.



Include temperature and “other factors” as “climate factors”

At L557-64, the authors seem to consider only precipitation and radiation as “climate change” factors. The numbers from that result in a pretty good correspondence to the results from Zhu et al. (2016), but I would be surprised to learn that those authors included only precipitation and radiation in their analyses. Later in that paragraph, the authors talk about temperature, but it’s unclear why it was not included before. Finally, “other factors” (wind speed and relative humidity) are not mentioned at all, but these are also climate factors. The authors should rewrite this paragraph to include all climate factors together in the initial analysis. (The final sentence is a good summary but should also mention “other factors.”)

“Grids”

In almost all instances, the authors should replace “grid(s)” with “grid cell(s).” “Grid” is more appropriate when describing the overall setup (e.g. “grid resolution” is fine), but for referring to individual 0.5° boxes, “grid cell” is what should be used.

In “Minor suggestions and technical corrections,” I’ve noted some places this should be fixed, but not all places.

Minor suggestions and technical corrections

- L82-4: This sentence is still confusing. “Global warming” seems to speak directly to temperature, but Keenan et al. (2017) found that slower temperature growth meant MORE C sequestration on land (due to lower ecosystem respiration). The Madani et al. (2020) bit is weird as well. Maybe “found that plants productively with water stress show a negative response to temperature rise in tropical zones” should be changed to “found that productivity showed a negative response to temperature in tropical zones due to increasing water stress”?
- L222: “10% **of** non-structural”
- L262,6: “tree” should be “trees”.
- Fig. 1: I’m glad to see the newly-excluded grid cells marked in white in this figure. Please add an indication to the legend and/or caption pointing this out.
- L332-3: “vegetation grid cells” doesn’t really make sense. Suggest changing “We defined vegetation grid cells as those whose largest component” to “We included grid cells whose largest vegetation component”. Also, refer to Fig. A6 here.
- L345: “grids” should be “grid cells”.
- L355: “We declare that” is unnecessary and can be deleted.
- L367: “showed” should be “shown”.
- L427, 433: “grid” should be “grid cell”.
- L428: “dominated” should be “dominant”.
- L430-2: “zones” should be “grid cells”... Unless the analysis looks at area (i.e., hectares or whatever), in which case it should say “land area” or something. “Zones” is confusing because it can also be used to refer to latitudinal bands. (I know you’re not referring to latitudinal bands because with 10 bands all your results would be multiples of 10%.)
- Fig. 8:
 - Now that you’ve improved the description, I understand what you were going for with panels B and D. The labels indicating the fraction of grid cells in each category (1.21%, 6.33%, etc.) should actually be changed back to how they were previously. “-1.21” etc. is confusing because it doesn’t have the percentage symbol, and incorrect because -1.21% of global area is impossible. Sorry for my confusion before.

- The caption says that the fractions are of global *area*, but in the text it sounds more like fractions of *grid cells*. (See comment above for L430-2.)
- Figs. 9, 10:
 - X-axis labels should indicate the range of values in each bin. This can be accomplished by either (a) changing each label to be, e.g., “0–0.1,” “0.1–0.2”, etc. or (b) moving the tick marks so that the tick to the left of a box shows its lower bound and the tick to the right shows its upper bound. I’d prefer (b), personally.
 - Suggest deleting “over the hydrological grid cells (Figure 1).” It’s poorly-worded and doesn’t really add anything.
- L467: “of historical” should be “of the historical”.
- L480: Is “maximum change magnitude of LVBC density” here saying the same thing as “fluctuation range” later? If so, define and use “fluctuation range” here.
- L486: “lived in aridity” should be “in arid”.
- L504-8: Where is it demonstrated that “aridity mitigation” is happening in semi-arid zones? This phrasing to me implies that semi-arid regions are becoming moister. I think what you mean is that semi-arid regions are less arid than hyper-arid and arid regions. Suggest rewriting: “Whereas LVBC decreases and WVBC increases in hyper-arid and arid regions (Figs. A7 and A8), causing a downward trend in LVBC:WVBC ratio, semi-arid regions see an increase in LVBC.” Note that “in all factorial simulations” in several places in this paragraph is unnecessary; it doesn’t contribute anything to the analysis here.
- L508: “semi-arid **regions**”
- L538: Delete “are”
- L541-2: Suggest deleting this sentence. It doesn’t add anything explanatory like what I was looking for.
- L547: “more dramatically” should be “relatively more” for clarity.
- L554: Please check whether “zonal” is correct here (referring to latitude bands) or whether “grid cell” should be used instead. (Similar: “zone” at L566.)
- L558: Where does this “over one third” number come from? The weighted average of results from 8b and 8d? I think you should add panels C and E to show the *total* C effects (or maybe put this an Appendix figure).
- L562-4: This sentence is confusing. Suggested rewrite: “This spatially compensatory effect of climate changes is consistent with a previous analysis (Zhu et al. 2016) which found that climate changes explain only 8% of the increasing trend in carbon storage of foliage at a global level but that they dominate the trend over 28.4% of global land area.”
- L566-7: This sentence is unnecessary and opinionated; please delete.
- L567: Revert “we suggest” to “our results reveal” or “our results show” or something.
- L579-81: A critical aspect is not just that light competition is high, but that *water limitation (competition) is low*. Indeed, that’s what *allows* high competition for light—

trees can grow in close proximity to each other (and thus shade each other) *because* there's enough water to allow each tree as much as it wants. Please include this in your explanation here.

- L592-4: Description of Madani et al. (2020) is still too vague. What exactly did they show? Compare the vagueness here to the excellent summaries you give for Humphrey et al. (2021) and Ma et al. (2021) in the following sentences.
- L599: “process of terrestrial ecosystem” should be “of terrestrial ecosystems”.
- L617: You don't have any way of showing that the underestimate of CO₂ fertilization would be “slight.” Unless you cite some other work showing that the N deposition effect is indeed slight, I would rewrite this to “which should cause an underestimate”.
- Fig. A5: Much improved. Last thing: Please edit the legend labels to be “0–10%”, “10–20%”, etc.