



EGUsphere, referee comment RC1
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Comment on egusphere-2022-359

Anonymous Referee #1

Referee comment on "Simulating long-term responses of soil organic matter turnover to substrate stoichiometry by abstracting fast and small-scale microbial processes: the Soil Enzyme Steady Allocation Model (SESAM; v3.0)" by Thomas Wutzler et al., EGU sphere, <https://doi.org/10.5194/egusphere-2022-359-RC1>, 2022

In this manuscript, Wutzler et al. present a simplification of the previously published model SEAM by assuming a quasi-steady state for the extracellular enzyme pool. The SESAM model builds upon the SEAM model with additional modifications to the enzyme allocation mechanism for the decomposition of litter and residue pools. The main results include reducing SEAM model complexity while retaining long-term (decadal) SOM dynamics (C and N) and microbial adaptation to nutrient-limited conditions using overflow respiration and dynamic enzyme allocation. Overall, I appreciate how the authors retained the effects of microbial diversity and kept a simpler model structure. Moreover, I admire the authors for their thoroughness of the analysis, especially on the bias with quasi-state assumptions. The methods and results are sound; however, the introduction and discussion need some attention.

The major shortcoming of the manuscript is the writing style. The discussion section needs significant revision. I have the following suggestion to improve the quality of the manuscript further; afterward, the manuscript should be reconsidered for publication.

- Consider modifying the title because the manuscript is more of a simplification of SEAM rather than upscaling. Or be specific what is being upscaled.
- Abstract and Introduction:
 - The first paragraph of the abstract deals with the spatial scale of the microbial processes, and then SESAM is proposed to fix issues with temporal scale (decadal dynamics). Please fix this. The same issue is in the introduction; first, the spatial scale is introduced, then a solution for the temporal scale. A better explanation is needed to link how pore-scale processes affect SOM dynamics at different time scales to motivate the simplification of SEAM.
 - P1L22: What is that discrepancy? Provide examples with references. Some introductory sentences are missing on how current "global models" implement microbial processes and what is already feasible. Without this context, the

- development of the proposed model does not make sense.
- Define what the temporal scale of processes is. Authors often use short-term and long-term vaguely.
- Methods:
 - sensitivity analyses often depend on the sample size. I wonder if 5000 was sufficient.
 - The maintenance does not require N in SEAM/SESAM, right? What would be consequence of if it did?
- Discussion:
 - The first paragraph in most discussion sections reads as the introduction. This should be deleted or put in context with the manuscript's results.
 - Discussion 4.1
 - L5 "At the heart of the interactions are soil microbial processes, and hence, these processes need to be represented in models of SOM dynamics". Is that a good enough reason?
 - L6 check *patters*,
 - L7 Which microbial processes are being referred to here? Please be specific.
 - L8 missing subject.
 - L9: "Many of these processes work on small" define small
 - L11: In my opinion, "abstract" is misused throughout the manuscript. I would prefer simplification of the model rather than abstraction. Quasi-state assumption leads to a simpler model structure. All models are abstract anyway.
 - L12: what is meant by mean effects?
 - P13L3: "neglects smoothing dynamics that occurs when explicitly modeling DOM and enzyme pools". Add reference.
 - P13L7: it is confusing to read *input* along with fluxes because 'decomposition functions' are functions of stocks, not *inputs*. If you mean litter input, then write litter input/s.
 - P13L8: "The fluctuation analysis revealed...." Convoluted sentence. Split into two sentences.
 - P13L11: What are those certain conditions?
 - Discussion 4.2
 - "Competition between microbial groups and adaptation of the microbial community *is one of those detailed processes* that have been shown to exert strong control on decadal-term SOM dynamics". Which of those detailed processes? Also, add references for "strong control on decadal-term SOM dynamics"
 - P14L5: delete "instead of respiring it to the atmosphere after those pulses"
 - Delete: "Studying and discussing how these pathways can be modeled and clarified using SESAM warrants a dedicated manuscript"
 - P14L13-14, why and how is this related to the results from this manuscript?
 - Discussion 4.3
 - "short time scales" vague
 - "Hence, microbial parameters need to be constrained by inverting models to larger scale observations". What is meant by inverting here?
 - "Currently, the free air enrichment time series are running about 20 years are getting long enough to calibrate and test models at decadal time scale" This sentence seems to be disconnected from the entire paragraph.
 - Discussion 4.4
 - "We think of ways how let it change together with othermicrobial properties of enzyme allocation". How does this sentence contribute to the manuscript?
 - The third paragraph in this section is not a discussion of results. It can go in the outlook, but it can also be removed entirely.
 - It would be interesting to see how the sensitivity of selected parameters varies in the short-term simulation, e.g., for the time scale of Figure 4, substrate pulse simulation. This would add interesting analysis to the sensitivity section

comparing short and long-term sensitivity patterns in parameter space.

- Outlook: Delete it or rewrite it. In its current shape, it is not adding anything to the story. It reads like a to-do list.
- Figures:
 - SOM should be the sum of all C pools, right? Even if microbial biomass, DOM, and enzyme pools are small.
 - Figure 4: How does CUE compare with different model formulations SEAM/SESAM/SESAM_NoEnzFlux for this simulation?
 - Figure 6. Why are seasonal patterns for SESAM not shown?
- Appendix:
 - A3b It is best to avoid `syn_Enz`, because when discussing NoEnzFluz scenario, it gets confusing that dec will zero.
- I strongly advise using a formal writing approach as text occasionally reads colloquial, and often author deviates from the main ideas. Streamlining the text and avoiding such diversion would help the reader better understand take-home messages .