Comment on bg-2021-51
Anonymous Referee #2

Referee comment on "Disturbance Triggers Non-Linear Microbe-Environment Feedbacks"
by Aditi Sengupta et al., Biogeosciences Discuss.,
https://doi.org/10.5194/bg-2021-51-RC2, 2021

General comments:

- This is an interesting paper and I think it represents an important advance in linking microbial community structure with function by using an experiment to support a revised conceptual framework. In this study, Sengupta et al. find that beyond a desiccation threshold, microbial communities experience strong homogeneous selection for a subset of taxa and respiration rates plummet. Interestingly, stronger deterministic selection (likely due to strong environmental filtering) is associated with reduced respiration (again likely due to strong environmental controls on this function), with a transition towards less favorable OM thermodynamic conditions as a putative mechanism connecting the community with the function. I enjoyed reading the study and offer more detailed suggestions below to increase the clarity of the manuscript.
- I know there is probably a word limit for the abstract, but having read it before reading the full manuscript, I was unclear about the study’s aims and how to interpret the results from the study. I think there are some really interesting results that perhaps could be more clearly articulated in the abstract.
- The introduction is somewhat long (11 paragraphs). As a reader, I was losing sight of the big picture. In particular, one major contribution of this paper is a modification of the Hall et al. framework, which I think is somewhat buried in the introduction. What about making an additional section (starting on Line 53) called "Refining the link between microbial communities and ecosystem functions" or something that would better emphasize the conceptual contributions of this manuscript?

Specific comments:

- Lines 11-14: Can the essence of the conceptual framework be communicated more specifically? Perhaps emphasize the causal linkages (from Fig. 1) so the reader will understand the context of the results presented in the abstract (see also line 21)?
- Line 16: Maybe specify that these are bacterial communities
- Lines 18-20: I understand what this means after looking at figures 3 and 4, but maybe “relationships among community assembly, respiration, and OM thermodynamics” could be rephrased slightly so it doesn’t appear to conflict with the description of respiration as a step function (line 18, referring to transitions with duration of drying). What about something like “While these responses were step functions of desiccation, we found that in deterministically assembled active communities, respiration was lower and thermodynamic properties of organic matter were less favorable.”? Just a suggestion, maybe the sentence is clear for other readers.
- Lines 38-42: Because of the crucial role that the framework by Hall et al. plays in this manuscript, I think the framework could be briefly described with a bit more detail here. It is somewhat difficult to keep track of what the Hall framework was prior to being modified here. Maybe a sentence clarifying that “Microbial membership influences community properties and microbial processes, which in turn regulate ecosystem fluxes; all of these components can be further modified by environmental variation (Hall et al. 2018).” This would also help readers who haven’t read Hall et al. 2018.
- Figure 1 is great, but is it missing a direct link from environment to function? Or is this implied by the combination of arrow 3 and 5?
- Lines 75-86: On the one hand, I understand the use of “emergent property” here because the relative influence of determinism and stochasticity is unpredictable on the basis of membership alone. But on the other hand, the relative contribution of stochastic and deterministic processes is a tally of the processes that shape microbial community membership, which could be said to emerge from the assembly processes. So, I suppose I’m getting turned around here about what is emergent: microbial community structure or the ecological processes that generate structure from which they were inferred? I’m not suggesting a change to this terminology, I’m just noting my conflicting thoughts about it and maybe looking for some clarification in the text on why the processes are an emergent property of the community, instead of vice versa.
- Line 344-360: I’m not sure I fully understand what to do with the CPI output. The writing here is clear. I get the concept, I get the computation of the metric, and I get the interpretation of the metric in terms of the relative contributions of each bioreactor. But I’m kind of missing an explicit statement of what the CPI values can tell us about microbial processes in temporally varying environments in this study. It tells us about the variation among replicates, which should, in principle, be rather low if the sediment community was well homogenized. But what would it mean (ecologically, in the context of the conceptual framework) if a CPI value was close to 0.5 or 1? Maybe a hypothetical example or some hypotheses relating desiccation frequency to CPI in the context of Fig. 1 (arrow 5) would be helpful.
- Lines 361-429: I appreciate the extraordinarily clear presentation of the results. It was a joy to read. Lots of interesting aspects of this study to weave together and it was very expertly done here by the authors.
- Lines 452-453: I think this is an important point that could be emphasized more strongly. Why is this particular aspect of the study so crucial? That many microbes in the environment are inactive, and that active microbes remain sensitive to abiotic stresses while also being responsible for ecosystem functioning seems like a key detail to highlight in the context of the framework.
- Lines 469-473: One reference that might be helpful for the discussion is Chase (2007) Drought mediates the importance of stochastic community assembly, PNAS.
- Lines 482-489: Great point. Yes, I think the environmental effects are strong drivers of the relationships observed here. There could also be a biomass effect if the desiccated treatments simply have fewer cells, most of which may be inactive due to desiccation stress.
- Lines 517-520: This is a really cool aspect of the study! Interesting way to show the link between desiccation in the environment and thermodynamic favorability for microbial growth.
- Lines 539-544: One thought about the CPI output here is that the difference between
the 31- and 34-day treatments is actually greater than their nearby position on the continuous x-axis might imply. The 34-day treatment experienced more or less constant conditions, and was only rewetted during the incubation. The 31-day treatment experienced a single pulse of water followed by a subsequent redrying event prior to the incubation. Perhaps this pulse generated among-replicate variation in the microbial community such that the reactor with high function was also very different in community composition. While homogeneous selection dominated this treatment overall, if the null model was constructed using all taxa observed in the study, it’s not surprising only a subset of these taxa was able to survive desiccation (hence low beta-NTI). But if different taxa survived in different replicates, this could explain the high CPI. Is raw beta-diversity (or a within-treatment beta dispersion metric) of the active community a better predictor of CPI than the beta-NTI metric for this study?

- Lines 556-558: Yes, very interesting hypothesis and I suspect this is likely to be the case as long as environmental stresses (like desiccation) are homogeneously distributed in space/time. If stresses are spatio-temporally asynchronous, you might find high CPIs as hot spots/moments shift in space and time in response to environmental forcing.

Technical corrections:

- Line 79: Seems like there’s a typo here. “is an emergent property” maybe?
- Line 107: “preferential use of OM”
- Line 141: “biogeochemically”
- Line 303: “reference framework graphic” should probably be “Figure 1”
- Line 467: “outcomes”