

Interactive comment on “Annual net primary productivity of a cyanobacteria dominated biological soil crust in the Gulf savanna, Queensland, Australia” by Burkhard Büdel et al.

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Dear Dr. Büdel et al. – I have reviewed your manuscript “Annual net primary productivity of a cyanobacteria dominated biological soil crust in the Gulf savanna, Queensland, Australia”, submitted to Biogeosciences. This paper tackles a challenging measurement problem: estimation of the net C flux of a biocrust community over a year in the field. Also, using a battery of controlled environment treatments, the authors determine the response of these biocrusts to moisture, temperature, and light. Overall, the authors find that biocrusts are a net C-sink in this environment, but net production is only observed for a portion of the year. The strength of the paper is that the

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authors have amassed an impressive amount of data and are one of only a handful of groups to complete this type of estimate. The weaknesses are perhaps due to a weak expression of why it is so important to conduct this measurement, and why other similar measurements have been scarce, and an occasional propensity to dwell on details without clear explanation of why they are important. Below, I provide several suggestions to help revise the paper.

Major comments: 1. I understand that this study does not fit the typical hypothesis test framework, but nonetheless the authors could ensure that readers comprehend the more interesting elements of this work in the abstract, introduction and throughout. We can be fairly confident that most persistent biocrusts have a positive C-balance, because if they did not they would cease to exist eventually. Readers may find it intriguing that despite this apparent tautology, it is difficult to actually observe net CO₂ uptake in biocrusts. This is distressing given that due to their extent, biocrusts may be non-trivial players in the global C cycle today, and almost certainly were major players in early terrestrial communities. We need this information.

The reasons are various, but 2 major ones are that the positive CO₂ uptake only occurs during a small part of the year in most studies, and it is difficult to separate C-balance of biocrusts from C-flux from organisms (microbes, roots) or minerals (carbonates) that occur below them. If the study is framed as outlined above, obtaining an annual measurement becomes much more intriguing to the casual reader and the importance of this endeavor is understood.

2. Consider standardizing terminology for the one year monitoring (also called “monitoring of gas exchange”) and the factorial experiment (also called “gas exchange under controlled conditions”). I might suggest “environmental manipulations” and “Field monitoring”.

3. Consider placing the material on P4 L8-13 in section 2.3, and P4 L14-21 in section 2.4. It might improve flow and understandability.

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4. P 4 L9 – Why were the samples stored frozen? This does not seem like a region where freezing soils are natural. Aren't you worried this exposure could have harmed or otherwise altered the samples?

5. I could benefit from a few more details about how the 21 samples were used. For example you say 9 were used for the environmental manipulations, and 11 were used for long-term monitoring. What about the 21st sample? Also, I understand you inserted different biocrust samples for different portions of the field monitoring. But why are the samples used for such wildly varying times, I would have thought each would be used about 1.1 months?

6. There are 10 figures, are they are really needed? The content of Figure 6 is mentioned by the authors several times, but it is not completely clear to me why the authors ascribe so much importance to these 3 days. Also, figures 9 and 10 could probably be combined into one 2 paneled figure.

7. There are times when I would like to see different pieces of information integrated, and another case where there is integration but I do not have all the information I need to understand it. Fig. 4. Provides plots of biocrust responses to different environmental gradients in a manner often used by this author group and associates. This is fine, but what I haven't ever seen is a plot integrating more than one of these variables in 3 dimensions. This would be a nice addition, if it could be done. Fig. 8 is a valiant attempt at illustrating responses to 2 environmental variables as a surface, but there is no explanation of how this was created (Kriging?); further, the plot contains many inexplicable peaks and valleys, often near each other. Does this suggest overfitting? Maybe more aggressive smoothing is warranted.

8. The discussion is not bad as written. You do address a key measurement issue, and hypothesize that the isolation of biocrust samples from underlying soil is the reason some studies find net C-uptake, and some find net C-loss.

I would have like to see you more fully develop a few other elements too (several

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of which you do address to some degree), for example the generality that biocrusts maintain their existence by attaining positive C-balance only during a portion of the year, and that often the gains over a year are marginal. This means that oft-cited slow natural growth rates likely are due to environmental constraints; only a minority of the year is actually suitable for growth. I would have like to see you advance some hypotheses for why different regions have different annual C-flux values. Related to this, one novel aspect of your study is that all other annual flux measurements were conducted in environments with cool season hydration. Finally, you could develop more your hypothesis about how expected climate changes might impact these naturally occurring biocrusts. It might be helpful to break the discussion into a few subsections devoted to distinct discussion topics.

Minor comments Throughout: I suggest using “cyanobacterially dominated” (adverb modifying adjective) or “cyanobacteria-dominated” (noun functioning to modify adjective), not “cyanobacteria dominated”(no hyphen, no adverb) P1L18 - remove “at” P1L19 - remove “during”, suggest replacement of “referring” with “corresponding” P2L21-23 – standardize terminology for net C-uptake, 3 different synonyms are used here P2L27 – This would be a good place to mention that apparent C-source behavior is probably due to the challenges of properly measuring biocrust C-flux P4L15 – your meaning is unclear in the phrase “making sure that the area related.range” P4L18 – suggest “drainholes” rather than “borings” P7L1 – suggest “monitoring” rather than “investigation” P7L29 – suggest “continuing” rather than “continued” P8L12 – that biocrusts are typically losing C does not mean that overall they are a C-source. P8L15 – Omit “When”

I hope you find these comments constructive – Matthew Bowker

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