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Comment

***Interactive comment on* “Biological soil crusts on initial soils: organic carbon dynamics and chemistry under temperate climatic conditions” by A. Dümig et al.**

A. Dümig et al.

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I read with interest this contribution, which presents results from a study aiming to i) determine the amount of OC fixation by biological soil crusts (BSCs) and the BSC-derived OC input into the underlying substrates; ii) characterize the chemical composition of OC in BSCs and substrates by applying solid-state ^{13}C NMR spectroscopy and analyses of the carbohydrate signature, and iii) assess the OC dynamic and timescales of BSC establishment. This work deals with a topic very poorly studied by the BSC community, and as such is a welcome contribution that helps to understand the role of these important organisms on the C cycle of those ecosystems undergoing initial

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development.

Answer: First of all, we thank the reviewer for the helpful comments and ideas on the manuscript, and the positive evaluation of our data set as well as the consideration that this is a suitable work to improve the understanding of the role of BSC organisms on the organic carbon cycle in initial ecosystems. We followed the suggestions of the reviewer in almost all cases.

The manuscript was an enjoyable read, and was well written for the most of it, albeit I found some typos and minor grammatical errors. Thus, I would advise the authors to have their manuscript thoroughly revised by a native English speaker. A reduction in the length of the ms would also be desirable to increase its impact, as some sections of the ms, particularly the results and discussion, are very long and are somewhat difficult to follow.

Answer: We are revising the manuscript with the assistance of a native speaker to eliminate typos and grammatical errors. We agree with the suggestion of the reviewer and shorten the manuscript.

I did not find major experimental or analytical errors, but since I am not an expert on the use of ^{14}C and NMR spectroscopy, I may miss some important details that need revision.

Despite the inherent value of the manuscript and the potential relevance of the results presented, the manuscript has a fatal flaw, which is the lack of replication of the transects surveyed in the natural and artificial dunes. The “replicates” from each location within the transect are indeed pseudoreplicates. As a result the manuscript is very descriptive, the authors cannot present formal statistical analyses and the results cannot be properly compared and generalized. I have no problems with descriptive studies, as I think that information such as that presented here is very valuable and will likely foster future research on the topic, but certainly a manuscript lacking proper replication is not suitable for a leading journal like BG. Do the authors have additional data col-

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lected from other dunes/independent transects within each dune? If so they must be included, so the data can be properly analyzed. If not, and unless the authors can provide a sound justification for the lack of replication, I am afraid that the data collected cannot certainly allow the authors to achieve the objectives of their study.

Answer: The experimental design of our study was based on the following preconditions of both sand dunes: the small size and the patchy distribution of biological soil crusts (BSCs were not continuously and not in abundance present). In addition, we had to sample large amounts of BSC and substrate materials (due to the low organic carbon content) to make the application of the methods (e.g. fractionation, ^{13}C NMR) possible. Moreover, the analyses are rather costly (^{14}C). Please see comments to Reviewer 2.

Thus, it was not possible to find a sufficient (and independent) number of BSC spots for each BSC type with respect to the performance of profound statistical analysis. Following these constraints of the natural conditions we sampled three replicates of each crust type within 1-2 m² to assess the small-scale variability of BSC properties which does apparently exist. However, by correlating chemical properties and radio-carbon against organic carbon as a measure for crust development, our study allows to identify mechanisms of BSC formation although we did not have proper replications.

Unfortunately, we have no additional data from other dunes. As we tried to explain before, it is not possible to establish additional transects within each dune.

Other minor issues are described below: 1) The abstract is very long and includes too many results. Please select those that are more relevant and/or interesting and highlight them there. Answer: We agree with the reviewer and focus on the most relevant results to shorten the abstract.

2) I think that there needs to be more of a “punch” in the final sentence of the abstract. I would advice the authors to add a sentence to highlight the new insights and advancements over previous knowledge this work provides.

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Answer: Indeed, we are adding a final sentence highlighting our new findings.

3) Line 61: Add some references to support this statement.

Answer: Done.

4) Line 76: BSC-dominated microsites are also an important contributor to total soil CO₂ efflux (e.g. Castillo-Monroy et al. 2011, Thomas 2012).

Answer: Done. We added this statement.

5) Lines 123-127: Please indicate the date of sampling.

Answer: Done.

6) Lines 258-259: Do not repeat in the results data that are already present in tables and/or figures.

Answer: Done.

7) Line 419: Please update these values with the more recent Elbert et al. (2012).

Answer: Done.

8) The discussion should be shortened and improved, as it is quite “plane” and descriptive, and there are not many clues on why the results reported are relevant and interesting for a leading journal such as BG.

Answer: Yes, we shorten the discussion section and focus on the novel findings which were obtained by using radiocarbon and ¹³C NMR. For the first time, these methods were applied on BSC samples from field conditions.

9) Lines 407-421: The authors discuss that “the net contribution of BSCs to the SOM pool is difficult to assess as net photosynthesis takes place for only short periods after sufficient surface wetting due to rain or dewfall events, whereas carbon losses through respiration can be large during other periods”. Does this mean that the approach used here can provide more insights or precise estimates than those reported by previous

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studies that conducted in situ measurements of net CO₂ exchange? This issue is not properly discussed, and the authors could clearly discuss what are the pros and cons of the approach they used compared to what others have done before.

Answer: Our intention was to briefly address the general challenge with the determination of the net C input into soil surfaces depending on the balance between C gains (photosynthesis) and C losses (respiration) per year. Our approach reflects the long-term balance between C gains and C losses or in other words it reflects the long-time balance of in situ measurements of net CO₂ exchange. Thus, our approach is different to the other one, and of course it gives no detailed temporal information about the net CO₂ exchange of BSCs. Interestingly, our values concerning the annual OC inputs were in the range of those from other studies.

Thus, we introduced a brief statement that our values of BSC-derived OC inputs reflect the long-term balance between C gains and C losses.

10) Lines 562- 568: This pattern is also commonly found in grasslands from Spain (e.g. Maestre et al. 2002, Castillo-Monroy et al. 2011).

Answer: Done. We introduced this statement.

11) The conclusions section is too long. Please encapsulate the main take-home messages in a few sentences.

Answer: We shorten the conclusion section and focus on the most relevant findings.

12) Check the reference list, I found some errors in the years of some references and in the way the authors spell the abbreviated name of the journals. Answer: Thank you. We check the reference list and correct the errors.

13) The x axis of Figs 2-4 is not very informative, and no guidelines are provided in the caption on the meaning of 1-5. Please check this and rewrite the caption and/or the label of the axis, so readers can fully understand the figure.

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Answer: Yes, the meaning of the numbers 1-5 is not clear. Therefore, we introduced the explanation (“The numbers of the x-axis represent the five sampling spots and development stages of BSCS”) in the figure captions.

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