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Biogeosciences Discussions

Interactive comment on "The CO_2 exchange of biological soil crusts in a semiarid grass-shrubland at the northern transition zone of the Negev desert, Israel" *by* B. Wilske et al.

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We thank the referee for the positive review and appreciate the critical comments. We agree with the referee in that more experimental work is needed to identify effects from BSC on the soil and the soil CO_2 efflux. However, the effects can be assumed to be very small and the microscopically small treatments required for such mechanistic investigations seem very complex. Hence, this part of BSC–soil interaction may be better approached by starting with laboratory and model studies.

Anonymous Referee #2: The authors studied the effects of moisture on biological soil crust CO_2 exchange. They found that the frequency of precipitation is important for crust to have a positive carbon balance. CO_2 fixation (uptake) by crusts compensated

for soil CO_2 loss via respiration during the winter time when plants are not active. Rain was more important than dew for stimulating crust CO_2 exchange. The study is interesting in that the authors examine the response of crusts to pulse frequency and the seasonal dynamics of crust physiological activity. I think it is also interesting that they explored the significance of dew for crust activity. They state that in situ field measurements are rare, but I disagree; I think there have been several studies that have conducted field measurements of crust physiological responses to rainfall. Nonetheless, crust studies are still fairly rare, so I support the publication of this paper in this journal. I only have a few comments (see below).

Authors reply: We think our paper contributes to further our understanding of the role of biological soil crusts and soil surfaces in controlling the exchange of carbon with the atmosphere. We agree that there were field studies published but do not want to argue whether the numbers of these studies are rare of fairly rare.

Anonymous Referee #2: The authors need to introduce what BSC are in the first line of the introduction.

Authors reply: We accept the comment of the referee, but it is to question what should be mentioned first. We propose to merge the two sentences into one: Vast areas throughout the semiarid and arid areas of the world are covered by so called biological soil crusts (BSC), which consist of communities of cyanobacteria, green algae, lichens, mosses, microfungi and bacteria in various proportions (Belnap et al. 2001a,b; Karnieli et al. 2001; West 1990).

Anonymous Referee #2: Rather than using the terms <CO_2 deposition>, I think it is better to use <CO_2 uptake>. Deposition makes it sound like particulate matter is falling on the ground.

Authors reply: The terms <emission> and <deposition> are widely used to describe the exchange of trace gases between biosphere and the atmosphere. We have to take into account that both terms describe the net result of bi-directional exchange which may have a mixture of biological, chemical and physical processes as background.

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Therefore we prefer to use these terms. Please see also our response to Referee #1.

Anonymous Referee #2: What is the <poikilohydric feature>; specifically?
Authors reply: For a better understanding we will rewrite as follows: BSC-forming organisms are well adapted to environments with unreliable water supply by their capacity to survive under changing tissue water contents, a feature which is called poikilohydry. This poikilohydric feature of cell-hydration allows perpetual cycles of desiccation and hydration without damage to biological functions (Belnap et al. 2001b).

Anonymous Referee #2: In situ field studies of crust response to precipitation have been done, so there needs to be better framing of the objectives.
Authors reply: We think the results of the study meet the objectives (p.1973, line 14–22) in that we can discuss a significant influence of the soil on the BSC hydration and BSC-related CO_2 fluxes. Secondly, the measurement system increased the data rate for BSC-related CO_2 fluxes, which allowed a better assessment of the CO_2 sink capacity as compared with the soil CO_2 efflux. The response of BSC to different amounts and frequencies of precipitation represents an additional important result. Although other studies reported and/or discussed similar observations, there are still open questions remaining. In this paper for instance, we mentioned the difference in water supply to BSC, which, relative to the frequency and amount of dew, may depend in large parts on the elevation of the site. Thus, we need even more studies to better understand the variety of reciprocal effects between atmosphere, BSC and soil.

Anonymous Referee #2: The authors state that a lot of studies (in situ) are done on loose substrate but their site has a high sand content.
Authors reply: According to Birkeland (Soils and Geomorphology, 1999, Oxford Press) a soil with the sand, clay, and silt composition as mentioned is categorized as loam. The term loam may indicate that the soil was not a loose substrate but particularly under semiarid conditions a tough and stable surface. The use of <loose substrate> rather referred to gravel or pieces of rock, which may be covered with e.g. *Ramalina* sp. in the Negev highlands. We will emphasize this point in a revised version.

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Anonymous Referee #2: I am not sure that the paired measurements of bare soil and crusted soil really capture the true crust CO_2 flux. The crust will affect the soil beneath so the crust + soil flux from the crusted soil is likely crust + crust affected soil + soil CO_2 flux. I suggest a statement about this caveat.

Authors reply: This is a most interesting comment. We believe we have answered the comment indirectly in our reply to Referee #1 and #2 by stating why we prefer to use the terms emission and deposition. Even if the effects suggested by the referee are much smaller than those of other processes, we are certainly inclined to believe that BSC affect the soil to which they are closely attached and agglutinated. However, we cannot identify such effects from our measurements, because during periods with relatively constant conditions of light, temperature and moisture, the results of direct differential measurements were not significantly different from the result that derived from the difference between single BSC sample and single soil sample measurements.

Finally, we like to emphasize that we used the term <BSC-related CO_2 fluxes> which may include both the active (related with photosynthesis and respiration) and the passive contribution of BSC to the fluxes. A type of passive contribution could be for instance an increased resistance to soil CO_2 efflux created by BSC growth. However, BSC did certainly not form a continuously impermeable seal. Higher resistance to CO_2 efflux would increase the CO_2 concentration below BSC, which could be compensated by higher efflux along gaps in BSC cover or even foster BSC photosynthesis in case they are active. These and other potential effects need more research and cannot be discussed in the present paper. However, we will emphasize in an additional sentence, that the term <BSC-related fluxes> may reflect fluxes including effects from BSC growth not related with BSC activity.

Interactive comment on Biogeosciences Discuss., 5, 1969, 2008.