Interactive comment on "Spatially variable soil water repellency enhances soil respiration rates (CO$_2$ efflux)" *by* Emilia Urbanek and Stefan H. Doerr

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We are grateful to both reviewers for their detailed and constructive suggestions, which will allow us to further improve the manuscript. We are pleased to note that the reviewers share our view that the study is novel, interesting and timely. The questions raised on the relationship and respective roles of water repellency and soil moisture suggest that we have not made it sufficiently clear which effects we have directly determined and which are implied from the results and established knowledge about soil water repellency. This is an issue that we will clarify more specifically in the revised manuscript. We agree with most of the specific comments provided and will implement the suggested changes. The main issues raised are listed below marked with (R#1 or

R#2) and our responses on how they will be addressed in the revised manuscript are marked with (#A). There are a couple of suggestions that we do not fully agree with and hope we have given a sufficiently thorough explanation for our reasons.

Response to Referee #2

The authors present a lot of data, which I find overwhelming. In my opinion, the manuscript would benefit from focusing, especially of the results section. Data that are not crucial for the explanation could go into supplementary information. This would guaranty that it is not an information overflow.

(#A) The changes suggested by Referee 1 already go some to focus the manuscript and we will revise the text to ensure further tightening. We do, however, feel that the figures included in the manuscript are necessary to understand the complexity of the phenomenon. It is already clear from Reviewer 1's comments that we have not made it sufficiently clear what is demonstrated by the data and what is inferred. The figures assist in making this clearer. Given that Referee 1 appears happy with the number of figures and has suggested some alterations to them, indicates the value of maintaining the figures in the main text.

The experimental setup as described in Figure 1 and Table 1: I have a hard time following why bracken and vegetated soil was measured, and also what the information on bare soil and vegetation soil was used for. E.g. Figure 4 presents data from which plots exactly? And Figure 5 displays forest and grassland plots in vegetated and bare plots but where are the bracken? Or is bracken vegetated? Please clarify which data were used when and why in a concise way.

(#A) We appreciate that the plot vegetation and surface bareness could be slightly confusing. First of all we have 2 sites: grassland and forest. Both sites have variable vegetation type cover (bracken and grass) which was thought important to be included in the study design given that the vegetation type may affect development of soil water repellency as well as soil respiration differently. As it can be seen on Figure1, 6 study

plots have been established at each study site, plots with bracken and grass vegetation cover. To differentiate the CO2 flux origin from accumulated litter and soil only, vegetation has been removed from one collar of each plot. The differences in SWR between bracken and grass were insignificant, therefore the results from all plots were analyzed jointly. After CO2 flux measurement for bare soil, the soil cover has been put back on the soil surface to allow litter leaching into the soil and reduce enhanced drying of the soil. Given that the soil samples were collected from vegetated part of the plot we were able to correlate CO2 flux and SWR distribution only from vegetated plots. We will clarify the text and the figures to better explain why soil under different vegetation were used for the study and which results represent joint and which the separate results from study plots.

- I think I miss an explanation why you chose to use temperature and soil moisture classes. It seems somewhat arbitrary at the moment.

(#A) Given that the measurements were conducted under field conditions the results of soil moisture and temperature had similar, but not exactly the same values it was necessary to group the results into the moisture and temperature classes. As with most classifications of environmental values, they are indeed essentially arbitrary, but facilitate comparison and interpretation of complex datasets. We will clarify this point in the revised manuscript.

- Figure 9: I understand the information in the figure and it seems a good explanation for the observed soil respiration patterns. Though, I assume the basis for this figure is the information on WTPT (Figure 4). But I don't understand how this information, which is based on WDPT tells you about flow paths. Please clarify

(#A) We like your suggestion to entitle the figure 'Theoretical framework of soil water distribution due to SWR and its effects on soil CO2 fluxes'. Referee#1 has also raised some questions about the conceptual model therefore we plan to amend this section and the figure to explain our understanding of effects of variable SWR and soil moisture

distribution on soil CO2 flux. As pointed out by the Ref#1 we will refer to soil water distribution rather than preferential flow in the 9b figure and we aim to amend the figure accordingly. We will also make some corrections to 9c figure and description to better visualize the water films and soil moisture content in soil pores.

Figure 2 - This figure is really busy and the shadings in different directions and colours are overwhelming. Consider putting the rainfall data in a table. Or/and present the temperature curves as mean +/- standard deviation as they are following each other closely anyway.

(#A) The business of the figure seems to be arising mainly from different patterns used. We wanted to make the figure grayscale printer friendly. We will revise the figure using colour, convert it into a table, or present two separate figures in the supplementary material as suggested.

Figure 3 - Suggest to move this graph to a supplement. I don't see a direct connection to the study other than that it presents the expected variation in soil moisture and soil temperature during the years.

(#A) We feel this figure is important and should remain in the main text as it shows important information for the reader about the measurement dates and puts them into a context with the moisture and temperature data. We will clarify this point in the text.

Figure 4 - Where are your error bars on the barplots? I assume it is the means of replicated samples?

(#A) Figure 4 represents the frequency distribution of all individual samples and replicates (not only averages) and therefore the use of the error bars is not applicable. The variability of the results between the samples is represented by different colors of the bar. This will be clarified in the caption.

Figure 5 - The presentation of soil respiration is challenging for the eye. Why not present boxplots? Picking out the means is very difficult in this way. Some sampling

dates seem to miss the mean altogether. Same as with Figure 3, I think this information could go into a supplement.

(#A) We also feel this figure is important in and should remain, however, we would be happy to make the suggested changes to the graph and to present the mean values more clearly and clarify its relevance more specifically in the main text.

Figures 6 following - You could combine figures 6, 7 and 8 to one figure with 3 panels. For figure 6, did you use data from bare and vegetated plots? How did you combine the soil respiration data? For figure 7, did you pool the forest and grassland data? Figure 8: how do you calculate the SWR distribution and what exactly does it mean? You mention it on page 8 line 8 but it is not clear to me how you calculate the distribution.

(#A) Thank you for the suggestion to combine the 3 figures into one graph panel. We agree that this it is a good idea and will combine it in the revised manuscript. We will also clarify which data have been combined and how the SWR distribution was calculated in the methodology section.

Figures 7 and 8: - Figure 7 shows soil moisture, Figure 8 shows SWR. To me, the information gained from both plots looks similar. What is the new information in Figure 8? I think I don't understand why you recommend the measurement of SWR (which is much more effort than SWC) if the same information can be gained from the measurement of SWC.

(#A) Soil moisture is expected to be very variable in soils with variable soil water repellency and that could cause a different heterotrophic respiration due to the patchiness of soil moisture distribution. Moisture content is clearly a key driver, but given that trends associated with climatic changes may lead to increased severity of soil water repellency, it is necessary to understand more fully what effect it will have on soil respiration. We feel this study makes an important first step in that direction, however, more studies in which water repellency is measured are needed to determine to what degree the patterns and implications highlighted in this study are applicable elsewhere.

(#A) The remaining and more specific suggested edits below will be addressed as recommended by the referee

Specific comments: - Page2 line2: the reference to Karhu et al is wrong. Karhu et al themselves cite the reference that you need here. Page 20 line17: where do you document the significant results mentioned? Page 22 lines 18-20: what could the biological controls be? Page 23 lines 12-14: reference to Figure 4: I can't relate the information in this sentence to any information presented in Figure 4, please clarify. Figure 9: the title of the Figure is misleading: The figure does not show soil CO_2 efflux responses. It rather shows a theoretical framework of soil water distribution due to SWR.