Biogeosciences Discussions

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Comment on bg-2021-259

Anonymous Referee #1

Referee comment on "Peat macropore networks – new insights into episodic and hotspot methane emission" by Petri Kiuru et al., Biogeosciences Discuss., https://doi.org/10.5194/bg-2021-259-RC1, 2021

This manuscript presents a thorough imaging and modeling study on pore networks in peat samples collected at different depths from a drained peatland, and uses this analysis to discuss implications of peat porosity and pore network characteristics on gas transport and methane production in peatlands. The manuscript is well written and easy to follow. The methods are explained well, although more details of error analyses and impacts of errors on the results, as well as some reconsideration of the statistical analyses would be needed (see specific comments below). My main concern about the presentation is that the results seem mostly intuitively obvious. It makes sense that porosity increases in peat towards the surface just because of how increasing pressure would influence and deform peat structures the deeper one goes in the soil layer. Maybe this has not been shown with the methods used in this study before, but the manuscript fails to communicate the state of the art in this kind of studies. This, combined with that one of the main results, the hysteresis behavior, seems to be just a model result with no verification based on the experiments, and the superficiality of the discussion on the connections between the porosity and network parameters and their impact on methane emissions and gas transport makes it hard to understand the importance and impact of the study. Was the goal to demonstrate what the used techniques can do? Or was it more to showcase a way to understand CH4 emissions? This same unclarity in focus is apparent from the figures. Figure 3 is clearly a model vs. measurement comparison, but it is discussed in the results as a figure presenting characteristics of the peat samples. Figure 4, on the other hand, is presented in a format that emphasizes differences in the peat sample properties, but is discussed in the text as a model-measurement comparison. To improve the presentation, I suggest that the authors clearly define the purpose of the study, and then build the text and presentation of data in the figures to support that goal. For example, to support the statements about Fig 1, the changes in porosity between depths could be more effectively presented as a box or bar plot with appropriate error bars and statistical analyses. And for fig 4, the model-measurement comparison would be presented more clearly by an x-y –plot. For the discussion, I suggest, again, focusing on the goal of the study. If the goal is CH4 production and transport, then some simple calculations about the impact of the

parameters measured here on the transport and emissions would be helpful. As it is, the discussion reads like a collection of separate paragraphs where the importance of more complex network parameters such as tortuosity or top-bottom betweenness centrality for CH4 production and gas transport are left unexplained, while some relatively obvious results, like that higher porosity lead to higher connectivity (lines 436-444) are discussed in length.

Specific comments:

Line 14: What was the hysteresis in relation to? What were the parameters that showed the hysteresis behavior?

Line 23: Please be more specific about how peatlands modulate or are modulators of hydrological and biogeochemical cycles. Why are they globally important?

Line 28: The line starts with repetition.

Line 39: Capability instead of characteristic?

Line 96: Why was the diameter of the sample only measured to determine shrinkage? Where the samples all the time in the plastic tubes? Why was the vertical shrinkage not considered?

Line 104: How good is the value of 1500 kg m-3 for particle density for these samples? Does it accurately represent all the sample depths?

Line 106: The assumption that air-filled porosity was zero in the saturated state is probably not quite true. Please give an estimate for how much that might be off in your samples and what kind of an error it would lead to in your results.

Eq 3. Why is this equation needed? Why is not the calculation using eq 1 not enough for the comparisons? How was this equation fitted to data? What were the fitted variables that were measured, and how were they measured?

Line 113-114: Why is it important to tell that the pressure range was so narrow that the fitting procedure needed to be modified? Why was a larger pressure range or a more appropriate fitting algorithm not used?

Line 118: Please move “noninvasively” to the end of the sentence.

Line 123-125: Please give an error estimate for what this darkening might do to your results.

Line 136: How did you deal with that the contrast between air-filled and water containing regions or organic materials was low? How did this affect your results? What kind of and how large an error could it cause?

Line 154: Why did you use the sum of distances? It is hard to visualize how this calculation what performed and what it means.

Line 158-160: Does this mean that the shrinkage of the samples was not taken into account here at all?

Line 164: What does the "largest of these clusters" mean? How was size defined? How does taking this part under analysis solely affect the interpretation of the porosity and connectivity results from the samples? Can this size be somehow standardized between samples to make them comparable? Can there be more than 1 large enough network in a sample that all of them should be considered?

Line 202: See previous comment. How does the defined region affect the connectivity analysis. How can you account for non-connectivity in a standardized sample size?

Line 234: Please explain more clearly how the one-way anova analysis was performed. Were all the depths analyzed simultaneously or did you perform pairwise tests between each. Would a multi-way anova with interactions included or a version of linear models give you more comprehensive results?

Line 242: Figure 3 actually shows a consistent underestimate of porosity by the model.

Line 254: Does water content here refer to the original samples, or saturated samples or dried samples, and at what depth?

Line 260: The hysteresis effect seems to be only a modeling result. Is that a feature of the model, or is there real experimental evidence for that this hysteresis happens?

Figure 6: I think combining the cumulative volume figures to one figure where each depth is described by one average line and error bars (or error shading) would be a mode effective way to present this data. It is not necessary to present data for individual samples here.

Lines 371-380: How do the results of this study relate to this text?

Line 442: Can anything else happen in networks than shorter pathways leading to more alternate routes?

Lines 454-459: How is this related to gas transport of CH4 production?

Line 494-495: How do you get to the conclusion that orientation in diffusion paths does not change transfer towards atmosphere?