

Biogeosciences Discuss., referee comment RC2
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Comment on bg-2020-438

Rutgers Newark (Referee)

Referee comment on "High-resolution induced polarization imaging of biogeochemical carbon turnover hotspots in a peatland" by Timea Katona et al., Biogeosciences Discuss., <https://doi.org/10.5194/bg-2020-438-RC2>, 2021

There is increasing evidence that hot spots of biogeochemical activity exert profound effects on ecosystems that are disproportionate relative to the physical footprint of the hotspots. Geophysical techniques have a role to play in locating such hotspots. Induced polarization is an interesting method as it may be sensitive to indicators of enhanced biogeochemical activity, such as the precipitation of metallic minerals where anaerobic and aerobic waters interact.

I found this paper interesting to read and it includes some nice graphics for illustration. My main concern about the work is that the attempt to correlate IP measurements with indicators of enhanced biogeochemical activity (in this case enhanced carbon turnover) is unconvincing based on the presented dataset. The paper focuses on correlating the IP-measured phase and/or imaginary conductivity with [1] vegetation patterns, [2] chemistry of soil samples, and [3] water chemistry. I could not follow the logic of the argument that the IP measurements are indicative of hotspots and I doubt that the assumed correlations are statistically significant. Figure 8 is presented to argue that the phase is correlated with the vegetation patterning – but how does that represent a hot spot? Figure 10 appears to be presented to show that phase is uncorrelated with fluid DOC, Cl⁻ and F_{tot} in the pore fluid and therefore is an indicator of biogeochemical hotspots (Lines 374-381). I could not follow this logic at all. Later in the paper, the entire upper layer of the soil is identified as a 'hot spot', which seems inconsistent with the idea that there are localized zones in space of enhanced biogeochemical activity. In summary, I really struggled to understand what how the presented dataset characterizes hotspots in this paper.

Another general problem I have with the paper is that I found myself often failing to see the apparent correlations drawn between the geophysical images and the other available site information. The inferred correlations were often unconvincing at best. As an example, on lines 550-551 the significance of a correlation between polarization response and DOC is emphasized, yet the real part of the conductivity shows the strongest correlation with DOC.

I also noted some significant technical errors that suggest some misunderstanding of induced polarization. One that was particularly concerning is the statement given at Lines 297-300. This is entirely incorrect. Ulrich and Slater (2004) and Kemna et al. (2004) definitely did not say this. This statement is particularly concerning as it implies a possible

misinterpretation of the IP measurements throughout the paper, which may explain why I really struggled to follow the arguments being made in most places.

Specific comments:

Line 94: Slater and Binley (2006) is an inappropriate reference – this paper has nothing to do with IP mapping of contaminant degradation

Line 160: Not sure what you mean here. Fig 2d shows waterlogged/saturated soils but that doesn't mean surface runoff is occurring. Looks pretty flat as expected for a peatland

Line 163: Why the difference in grid resolution?

Line 164: Unclear, what experiments are you referring to?

Lines 184-185: I cannot follow the significance of the averaging described here

Line 210: check formatting of prime symbols on conductivity terms – currently strange

Line 218: The 20 cm electrode spacing is very hard to get right in the field conditions like those shown. What were the positioning errors and how were they incorporated into the processing?

Line 248 and Fig. 4: Line 248 refers to a normalized resistance but caption of Figure 4 suggests Fig 4c. is plotted as absolute resistance difference. Clarify.

Line 264: b is shown as a percentage value but previously defined as a relative error (as needed for the equation)

Line 265: Why choose this value for cumulative sensitivity? No justification given.

Line 281: You don't have a depth unit – maybe a 'deeper' or 'relatively deep' unit

Line 284: Is the porosity of the granite known or simply inferred?

Line 288: I don't see the correspondence between the electrical imaging and the contact with the bedrock that is being inferred here

Lines 292-293: I don't really see this evidence for higher polarization values in the northern part of the profiles relative to the southern parts

Line 296: Why 'roughly'? At the small phase angles you measure it is almost exact – any differences are well below your measurement resolution.

Line 305: What do you mean 'with higher resolution' here? Why would the phase images be higher resolution? This is unlikely given the relative errors in phase measurements relative to electrical conductivity measurements.

Line 331: what is meant by 'high electrical response'?

Line 336-337: Maybe. But could it simply be that some other common property influences both vegetation pattern and IP signal

Lines 372-373: sentence is not correct as there are no phosphate results for S3

Lines 374-381: I don't follow the argument that what is written here means that high phase values can be interpreted as biogeochemical hotspots

Line 390: previously you refer to upper 10 cm

Lines 409-411: Need to modify sentence as no phosphate levels for S3

Line 434: What do you mean by IP response here? Phase? Imaginary conductivity?

Line 458: What about the solid phase iron?

Lines 468-482: This material belongs in the Introduction/Background to IP rather than in the Discussion

Lines 527-528: Not necessarily the case for iron minerals. Point of zero charge for iron is around 8

Line 534-535: Published work supports that in silica-dominated systems pH influence is indeed small

Lines 550-551. This makes no sense to me – the DOC correlation is stronger with the real part of the conductivity.

Line 570-571: Is a layer really a hotspot? It rather destroys the concept