

Hydrol. Earth Syst. Sci. Discuss., referee comment RC1  
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## Comment on hess-2021-233

Anonymous Referee #1

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Referee comment on "An inverse dielectric mixing model at 50 MHz that considers soil organic carbon" by Chang-Hwan Park et al., Hydrol. Earth Syst. Sci. Discuss.,  
<https://doi.org/10.5194/hess-2021-233-RC1>, 2021

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### General comments:

This study developed a general inverse dielectric mixing model that can be applied to retrieve soil moisture from in-situ dielectric data. Considering organic carbon is the novel part of this approach. Overall, I think it is an interesting study. A reliable dielectric mixing model for organic soils is highly needed in order to get accurate soil moisture estimates in the high latitudes from both in-situ sensors or spaceborne microwave sensors. However, there are quite a number of places in the mathematical expressions that should be carefully examined. The data used for validation also have a very limited range of organic carbon content ( $OC < 0.06$  g/g), which are generally not classified as organic soils (rather they are organic-rich mineral soils). If the authors claimed this approach is going to help the soil moisture retrieval in the boreal and Arctic region, more data with a wider range of OC content are needed. Comparison with previous approaches that incorporated SOC (such as Bircher et al. 2016) should be also included and discussed.

Bircher, S., Andreasen, M., Vuollet, J., Vehviläinen, J., Rautiainen, K., Jonard, F., Weihermüller, L., Zakharova, E., Wigneron, J.-P., and Kerr, Y. H.: Soil moisture sensor calibration for organic soil surface layers, *Geosci. Instrum. Method. Data Syst.*, 5, 109–125, <https://doi.org/10.5194/gi-5-109-2016>, 2016.

### Specific comments:

1. Comments on the equations:

(1) Eq (5) and (6): it is confusing whether this applies to 50 MHz, or any frequency ranging from 1.4 GHz to 50 MHz. Also please provide the original references for these two equations.

(2) Eq. (8) does not seem correct to me. The correct equation should be:  $v_{\text{som}} = 1 / ((1/\text{SOM} - 1)(\text{BD}_{\text{SOM}}/\text{BD}_{\text{soil}}) + 1)$ , where in the original equation, the  $\text{BD}_{\text{soil}}$  and  $\text{BD}_{\text{som}}$  should switch. The authors should also clearly define " $\text{BD}_{\text{soil}}$ " and " $\text{BD}_{\text{SOM}}$ ". If " $\text{BD}_{\text{soil}}$ " is the soil bulk density, it varies greatly based on the SOM concentration, and using a constant value is not proper. Rather, I think here " $\text{BD}_{\text{soil}}$ " and " $\text{BD}_{\text{SOM}}$ " should mean the specific density of "mineral" and "organic matter" part of the soil solids. Please double check this.

Eq. (9): if this equation is used to estimate the soil bulk density for organic soils, it is not applicable to highly organic soils. E.g. when  $\text{SOM}=1$  (or  $\text{OC} \sim 0.58$ ),  $\text{BD}_{\text{SOM}} > 2 \text{ g/cm}^3$ . The original reference does not include data with  $\text{OC} > 20\%$ . This is also a common problem in the empirical equations derived for organic soils or organic-rich soils.

There is no equation (10).

Eq. (11) & Eq (12): similar as above, the authors should mention under what OC range those equations can be applied to, esp. the estimate of wilting point. For soils with high SOM concentration, Eq. (11) gives a very large estimate, which is even close to the porosity provided by Eq. (12).

2. Line 185: the authors should provide a brief description how the field estimates of OC was derived.

3. SoilGrids data: Does the author use SoilGrids 1km or SoilGrids 250m? The authors indicates SoilGrids1km in one place, while it says SoilGrids250m data were used in another place. These two datasets can be quite different in terms of OC estimates. Besides, SoilGrids1km provide OC estimates at certain depths, while SoilGrids250m provides OC estimates for different soil intervals. Please clarify.

Fig.2 (b): please provide colorbar for the OC map.

4. Comments on the results:

(1) Fig. 5 (a) what are the results derived using the Seyfried model? The red dots?

(2) Fig.6 & 7: the reduction of the uncertainty in SM estimates is relatively limited. It may be partly due to a narrow range and also a low amount of SOM in the soil samples in the study area.

Therefore, it needs additional investigation whether this method applies to highly organic soil (e.g. SOM>30%), prevalent in the boreal and Arctic region, and how it performs if it is applicable. I would think this method is more general and has a high potential applicable to those conditions. However, the parameterization (including the wilting point, porosity) needs additional improvement. It will be also helpful if the authors can compare their results with the previous methods that particularly incorporates organic carbon content. For example, in Bircher et al. 2016, the data do not show substantial dielectric differences in soils with SOM<30%, while this study shows even a small amount of SOM (SOM<~10-11%) can make a significant difference in the relationship between SM and dielectric constant.