

Interactive comment on “Dielectric characterization of vegetation at L-band using an open-ended coaxial probe” by Alex Mavrovic et al.

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GENERAL STATEMENT

This paper presents the development and validation of a new open-ended coaxial probe for in situ measurements of the relative permittivity of tree trunks at the microwave L-band. Such measurements are very important to support the decoupling of the integrated signal originating from soil and vegetation. The latter is an essential step in microwave remote sensing applications aiming at soil moisture observations and freeze/thaw detection, since the vegetation contributes to microwave brightness temperature measurements and scatters and attenuates ground surface emissions. The here presented measurement technique can help to improve the generally poorly

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parameterized vegetation canopy radiative transfer models that are used to exploit the satellite data. The paper is well written. The work is conducted carefully, critically reflected and underlined with relevant literature. It is without question of value to the satellite data calibration and validation community. I hope the authors will pursue their work as stated in the conclusions - having a single instrument able to measure the L-band relative permittivity of both soil and vegetation in situ would indeed be very helpful in the scope of better parameterization of microwave radiative transfer models. I suggest minor revisions of the manuscript to address the points raised in the specific comments detailed below.

SPECIFIC COMMENTS P=Page, L=Line

Section 1 - Introduction:

P3, L12-13: I remember a presentation given by Roger Lang at the MicroRad Symposium in 2016 where I believe he presented microwave permittivity measurements of trees in connection with the SMAP mission. When quickly googeling, I found this reference: Francois, A., Pineiro, Y, and Lang, R. H. (1998). Microwave permittivity measurements of two conifers. IEEE TGRS. But given his talk at the symposium, I assume there might also be more recent publications by this team. You could possibly add a respective reference.

Section 2 - Open-ended coaxial probe:

P4, L5-11: You state “The real part of the permittivity describes the effect of the reorientation of the electric dipole inside the medium that drives wave propagation, and the imaginary part describes the absorption (or loss) by the medium... A high value of real permittivity characterizes a medium that strongly resists the application of an external electric field (i.e. permittivity of water ≈ 90). In contrast, a low real permittivity characterizes a medium that does not strongly resist the application of an external electric field (i.e. permittivity of air ≈ 1).” I would have said that that the water molecules rotate well with an applied electric field due to their strong dipoles, which for me is the

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opposite of a resistance...?

Figure 2: in the caption you list b) before a). Furthermore, mention SMA connector, N-type connector and RVNA control program in the text (not only in the figure). Also, in the text you state that the gap is filled with PTFE, in the Figure you use the term teflon – better harmonize.

Section 3 - Methods: Personally, I struggle a bit with this section title. Since the goal of your paper is to “develop and validate a probe” in my opinion sections 2.2 and 2.3 are also part of the applied methods... Maybe you could rather call section 3 “Tree permittivity measurements with open-ended coaxial probe” and section 3.1 something like “Measurement principle”.

P7, L27-31: Since one of the objectives of the paper is the development of the probe, you could possibly add one figure demonstrating the good reproducibility described in the text.

P8, L7-8: I assume the plumber’s putty used cannot affect the measurement? What does its relative permittivity look like?

P8, L21-23/Table 1: From Table 1 I assume you took the measurements at breast height. Possibly add this to the text. If you have taken measurements at different tree heights, could you see any trend or do you get the same measurement result everywhere? If you later want to determine the bulk contribution of the trees to the microwave L-band signal observed by space-borne radiometers, then you would certainly need to check this. I see that this does not necessarily fall into the scope of this paper, but I think it would be interesting to the reader if you added some lines on this issue (if ever you have already tried to measure... at different tree heights to see if there is a difference).

Section 4 - Results:

P9, L3-10: What do you exactly mean by “For this reason, all results shown in this

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article were taken with samples of thickness greater than 10 mm”? Is this why you give the DBH in Table 1? In Section 3.2 you only mention that you drilled at several depths. In Table 3 you indicate an average permittivity across the whole tree... It would be nice if you could be a bit more precise on the different measurement depths. In that context, it would also be useful to list the respective sapwood thicknesses estimated visually using tree cores extracted with an increment borer. Could you possibly add this information together with the respective drilling depths to Table 1?

Table 3: “average value across the whole tree” - I assume you mean from the bark to the center of the stem as can be seen in Figure 7?

P9, L32-34: “In the first several millimeters of the trunk, sapwood permittivity is higher due to a high water content, but permittivity decreases quickly to a lower and well-constrained value in the heartwood (Fig. 7). “ → I guess the closer you get to the heartwood, the more your penetration depth approaches the max. estimated as 9 mm. Does it mean that close to the border between sapwood and heartwood your measurements - even if still taken in the sapwood - can be influenced by the much drier heartwood, i. e. resulting in a bias towards lower permittivities?

P10, L16-20: “However, it should be noted that L-band penetration depth in thawed trees is limited to 10 mm according to Eq. (1). Therefore, it should not exceed the sapwood depth, which suggests that the sapwood permittivity could be considered as the actual effective permittivity of trees with regards to L-band interactions. Consequently, the average permittivity reported in Table 3 for different thawed species was estimated by averaging the permittivity through the first centimeter under the bark using a trapezoidal numerical integration over that first centimeter. ” → I had to read this several times to understand what you mean, maybe consider to rephrase to make it clearer. In line with my comments further above (P9, L3-10 and P9, L32-34) I think it would be really helpful to indicate the sapwood depths of all sampled tree types in a table (and not only in Figure 7 for black spruce).

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Figure 8: The color coding of the different soil moisture measurements could be improved. However, I was general wondering, is it actually necessary that you show all these different soil moisture measurements? They all exhibit the same temporal trend, demonstrating the rain events, and if I understood correctly, that is their purpose here. Thus, one curve would be sufficient. If you keep the vertical probe, then I think you should indicate the sensing depth interval.

Section 5 - Discussion:

P12, L33-36: "The potential for modifying the dimensions of the probe is limited because probe frequency is geometry dependent. However, it should be possible to reduce the dimensions of the probe for less invasive measurements by increasing the probe frequency." → I do not understand what you want to say here. The two sentences sound a bit contradictory to me...

Supplementary material:

Figure S7: If I got it right this plot corresponds to the data presented in Table 3? if so, you could indicate this in the caption. Why are you not providing the same plot for the 1cm average under thawed conditions?

Only Figure S5 is referenced in the text → possibly add respective references to the other supplementary figures as well. That way it is clearer why you provide them.

TECHNICAL CORRECTIONS

Section 2 - Open-ended coaxial probe:

P5, L4: Define ϵ

P5, L6: f is not part of formula (1)?

Formulas 2-4: check that all parameters are defined in the text

Formula 5: There are two formulas number 5 (P6, L8 and P6, L15)

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Section 4 - Results:

Table 2: I assume it should read "...in Fig. 5 and 6" (instead of Fig. 7 and 8).

P10, L7: should it read "awakening" instead of awaking?

Section 5 - Discussion:

P11, L11-12: "L-band wavelength is about 20 cm; branches need to have a diameter at least a significant fraction of the wavelength to influence the signal, which is not the case" → there seems to be a word missing in this sentence

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