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Hydrology and Earth System Sciences
Discussions

Interactive comment on "Small scale characterization of vine plant root water uptake via 3D electrical resistivity tomography and Mise-à-la-Masse method" *by* Benjamin Mary et al.

Anonymous Referee #2

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Dear Authors,

This article tries to develop a new tool to map and quantify active root distribution using as model plant the grapevine. Thank you for your effort. The problem you are trying to address is very meaningful to a number of disciplines. The combined use of MALM and 3D ERT is very novel for this purpose, it is state of art and it was worth trying.

You are addressing a very multidisciplinary problem, but the plant science/agriculture/soil science section is lacking, from a practical (no data on roots) and conceptual point of view (the assumption that only fine roots could conduce). Claiming that a tree such as the grapevine would have such a shallow rooting depth, it is

very, very hard to believe, and is in contrast with the published literature and not in agreement as you state.

The paper is very advanced from the geophysical perspective, however it sounds more like the presentation of preliminary data then the report of an accomplished work. The text continuously refers to roots, and the goal of the paper is mapping roots, but there is not a single figure showing a root map obtained through the method, only voltages and misfits. Authors do not bring evidence that their image is root related, why it could not be just noise? Why the root system was not excavated to confirm your imaging? Why there are no measurements on the root system at all?

The article is well written, figures are of good quality, but in my opinion the article cannot be published in the current form. Bringing root data would oblige repeating the whole experiment, as roots of the measured plant would have changed in between. In this case, author should take into account that measuring a single plant would not be enough, because of biological variability. Without a new field campaign, the text should be completely rewritten. Authors should avoid to speak of roots if not as the ultimate research goal in order to be coherent with the data presented which are only of geophysical nature. However, once rewritten from an exclusively geophysical point of view the text will be very technical and much less interesting to the wide audience of this journal.

Abstract:

The abstract is very generic. It does not give clear indication of material and methods, neither of results. The evidence from field data: it is not clear why the voltage distribution support the hypothesis, as current is injected in two different media. "in agreement with literature on similar crops" is simply not enough, authors should have measured the plant under investigation, and also repeated the experiment with more than one plant to deal with the biological variability.

Introduction:

The stated problem is very wide and generic. This paper deals with the development of a new method for the 3D mapping of fine roots, which constitutes the most active part of a root system from a hydrological and biological point of view.

I would not call MALM non-invasive, as a stainless steel rod needs to be inserted in the stem, and what is presented in picture 2 does not look as a small intervention either. Would a steel ring be adaptable to the technique?

Section 1.2. This section reviews attentively the precedent literature on the use of geophysical methods for morphological monitoring of roots, however some more is needed on the use of geophysical methods for observing root activity (nutrient and/or water uptake) which is notably neglected in this section.

P2L13. clay content: the Archie law does not really account for clay content, conversely the matrix is supposed non-conductive, Waxman and Smits were probably the first authors to account for this. Temperature also is not present in the Archie law, and the cementation exponent is supposed independent from temperature effect. Generally the study of the effect of temperature is reported to

Campbell, R.B., Bower, C.A., Richards, L.A., 1948. Change of electrical conductivity with temperature and the relation of osmotic pressure to electrical conductivity and ion concentration for soil extracts. Soil Sci. Soc. Am. Proc. 13, 66–69.

P2L14. In my opinion the use of the term pedotransfer functions here is wrong. Those are petro-physical (mechanistic) models. You could use pedo-physical, but these works were done for geological more than soil investigation. Recent works on electrical pedotransfer functions also including the relationships with soil properties you are interested in, may be found in:

Hadzick, Z.Z., Guber, A.K., Pachepsky, Y.A., Hill, R.L., 2011. Pedotransfer functions in soil electrical resistivity estimation. Geoderma 164, 195–202.

Brillante, L., Bois, B., Mathieu, O., Bichet, V., Michot, D., Lévêque, J., 2014. Monitor-

ing soil volume wetness in heterogeneous soils by electrical resistivity. A field-based pedotransfer function. J. Hydrol. 516, 55–66.

P2L17. acronyms must be capitalized when written in full at first appearance

P2L19. There are works from the same authors for the mapping of tree roots, that actually came first. However, their method in my personal experience has been difficult to replicate. Especially in heterogeneous soil-moisture conditions that are the frequently the conditions of these studies. Furthermore, the method is very labor intensive and destructive, as it demands a direct calibration with roots from soil cores.

Amato, M., Basso, B., Celano, G., Bitella, G., Morelli, G., Rossi, R., 2008. In situ detection of tree root distribution and biomass by multi-electrode resistivity imaging. Tree Physiol. 28, 1441–1448.

Rossi, R., Amato, M., Bitella, G., Bochicchio, R., Ferreira Gomes, J.J., Lovelli, S., Martorella, E., Favale, P., 2011. Electrical resistivity tomography as a non-destructive method for mapping root biomass in an orchard. Eur. J. Soil Sci. 62, 206–215. https://doi.org/10.1111/j.1365-2389.2010.01329.x

P2L19-20. The cited work from Cassiani does not report resistivity$\sim$root correlation/calibration. How could this paper demonstrate the reliability of the method as in Amato and coworkers?

P2L23-26. is very interesting and you could also expand considering the case of soil with heterogeneous moisture or soil properties that would complicate further the calibration with root mass

P2L32. It is not clear if you are speaking of the resistivity of roots in soil (and at this point there is also the effect of the mass), or of a root fragment in itself.

The term dead wood is not correct, you could just use "heartwood and the pith"

P3L4-6. citations needed.

P3-L25. “sap flow processes take place at the cambium” is not correct, sap flow happens in xylem and phloem which are from either side of the cambium.

P3L27-28. “the quasi-infinite connection” is this your assumption? In this case needs to be clearly stated, or you could cite the paper that addresses this.

P3L29-30. This may eventually be considered a strength of the method, as fine roots are the active ones, people in plant sciences would be interested to measure. You could put this more in evidence.

P4L8. xylem and phloem sap, as xylem and phloem are not fluids. P4L27 Maybe this citation would be interesting for future readers:

Postic, F., Doussan, C., 2016. Benchmarking electrical methods for rapid estimation of root biomass. Plant Methods 12:33. https://doi.org/10.1186/s13007-016-0133-7

Material and methods:

The biological material and agricultural system needs to be better described (how old are the plants, what is the distance between them, what shape size the canopy, what is the rootstock?)

2.1.1 Interpreted soil picture needed

P3L11. “colluviosol” is not international nomenclature. Please correct using IUSS Working Group WRB, 2014. World reference base for soil resources 2014. International soil classification system for naming soils and creating legends for soil maps, World Soil. ed. FAO, Rome

P3L11. Measurement of root density is key in this paper. How this was performed needs to be detailed.

P3L13. What is “dense rooting for you?” please specify

P3L14. The term horizon instead of layer would be more scientific (from now on)

P3L17. “terroir de grave” not clear what this is. Is this a term for a distinctive geological or pedological formation that is meaningful in local terminology? If this is a local term needs to be reported in italics and quoted

P3L18. Only one plant??? That is far under the minimum for characterizing a biological systems, and even if you just want to show that the method is working how could you claim that is not just by chance?

P3L19. "sandy-clayey horizon" although correctly identifying and naming it would be better

P3L21. English not clear (top layer rooting). Do you mean "asymmetric root development in the top layer"?

Sections 2.2 and 2.3 In agreement with Reviewer 1 the geophysical acquisition and inversion procedure is not detailed enough to be replicated by new authors. This must be better detailed. Are you considering to share the MALM inversion code with this article?

Results:

P10L9-11. A root system with a lateral extension of 0.5-0.9m appears reasonable (considering the density of plants in figure 2), however no active roots deeper than 0.3m, in a non-irrigated permanent tree it is a very striking and conflicting result. In my opinion this is not true, as I am not even sure that in a tilled soil, with grass in the inter row (figure 2) you will find the majority of tree roots in the first 0.3m. The problem here is that authors did not excavate the rootzone to demonstrate their measurements. Very few examples are reported here:

Water depletion and contribution to plant water status is observed under grapevines at 1.5m using electrical resistivity tomography in Brillante, L., Bois, B., Lévêque, J., & Mathieu, O. (2016). Variations in soil-water use by grapevine according to plant water status and soil physical-chemical characteristics-A 3D spatio-temporal analysis.

European Journal of Agronomy, 77, 122–135.

Old-school maps of grapevine roots down to a depth of 1.5m (in irrigated conditions) can be find in Rob M. Stevens, Tim Douglas Distribution of grapevine roots and salt under drip and full-ground cover microjet irrigation systems. Irrig Sci (1994) 15:147-152

Using magnetic resonance imaging root activity is already observed at around 30cm depth in just 20 days old Lupinus alba seedlings, (Carminati A (2013) Rhizosphere wettability decreases with root age: a problem or a strategy to increase water uptake of young roots? Front. Plant Sci. 4:298. doi: 10.3389/fpls.2013.00298)

Using modelling and isotopic approaches the mean relative contribution to transpiration of soil layers under 0.4m is estimated around 50% in Rothfuss and Javaux, 2017 Reviews and syntheses: Isotopic approaches to quantify root water uptake: a review and comparison of method Biogeosciences, 14, 2199–2224, 2017

P10L15-16. This work does not show that MALM can provide anything useful to discriminate spatial distribution of roots if not lateral extension within the first 30cm of soil depth.

P10L27-30. There is no evidence in this article “that injecting current in the plant stem causes a distribution of electrical current sources in the ground that correspond to the location of active roots.” Although I would eventually agree with this author suggestion, there is not theoretical argumentation to sustain this in this text, neither experimental evidence.

P11L5-14. This is well written

P11L17-19. This is not true, as also through the bark there can be some, small water uptake, which could allow electrical flow. Cuneo et al., 2018, Water uptake can occur through woody portions of roots and facilitates localized embolism repair in grapevine. New Phytologist, 218(2)

P11L19-22. Interesting field of research

P11L24-25. Slightly narrower range?? See previous comment, also when referring to literature, please cite at least one article!

P11L25-26. Out of context. No data to support the sentence. Remove.

P11L33. This is sure

P12L8. Interesting field of research

Conclusion:

Avoid to repeat the methods in the conclusion

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