Dear Editor Prof. Garré, Dear Reviewers,

We thank you the reviewers for the very helpful and detailed review, and general positive feedback. We hope our response and minor changes will be adequate and express our appreciation.

Reviewers' comments are in bold, authors' responses in regular font, and quotes from the article are in italics.

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Response to Emmanuel Léger (RC1)

Dear Editor,

I carefully read the Manuscript entitled "High-resolution near-surface electromagnetic mapping for the hydrological modeling of an orange orchard", from Peruzzo et al.

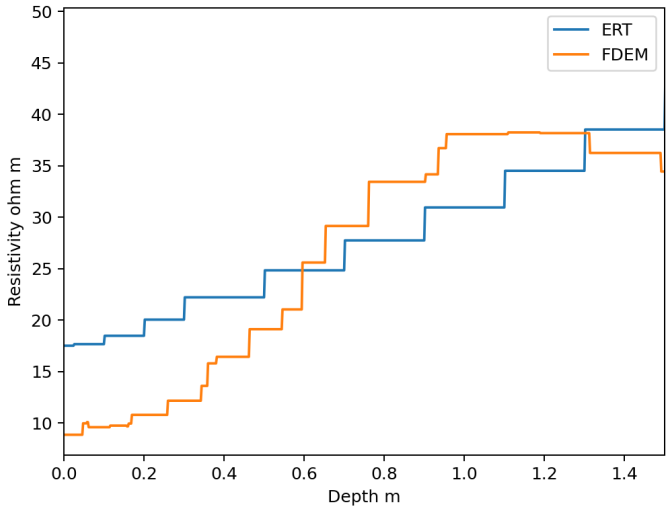
The paper is well written, and show a very serious study on EM processing, which is too often not done that deep. I had more difficulties to follow the Discussion section which seems to me more collection of conclusion items related to the what has been done in the field, but I may have missed something. I recommend publication after minor corrections. The paper will be cited for the excellent EM processing.

Please find a couple of comments a way to improve the paper, the first ``major'' comment need to be addressed with more care probably :

Major :

Line 448-449 : ``These contrasting resisty values and their spatial distribution agree with ERT inverted in Figure 6.'' If you want to state that you probably need a bivariate plot, Em versus ERT and/or a deeper statistical analysis.

Done. We agree that the statement was overly generic, we rephrased it to clarify the aspects that are of interest and directly evident from the comparison of fig 6 and 7. We tried to plot the FDEM and ERT resistivity profiles (at a plant position to capture the discussed RWU effect). In our opinion, it does not add much; the figure below shows 1) that the ranges agree and 2) that the profiles also agree. This is now more accurately stated, and visible from the two figures 6 and 7. The below figure also shows a combination of the expected water vertical redistribution (as the FDEM survey was performed after the ERT surveys, as described) and larger smoothing of the FDEM profile, related to the lower vertical resolution relative to the ERT with 20-cm spacing, which is expected and motivated the ERT. These two aspects were also included.



The sentence now reads as follows (L459)

The FDEM resistivity trend from the shallow irrigated layer (~15 Ω m) to the deeper and drier RWU regions not yet reached by the water infiltration (~45 Ω m) agrees with the ERT inverted section shown in Figure 6. Small ERT vs. FDEM differences are observed and expected due to the vertical water redistribution between the ERT measurements and successive high-resolution FDEM surveys, but also because of the higher resolution of the ERT surveys with 20-cm spacing relative to the FDEM, and consequent different model discretization and inversion smoothing.

I have a couple of minor corrections :

- L43-44 [...] AI drove'' I'd add ``and drive''

Done.

- L55-66. I did not understand why you chose to mention so much the cosmic-ray method ? It is a very goo paragraph, in term of references and sciences, but I tend to think that you insisted too much in regards with your paper, very much EM focused?

We find it relevant in general, even if not strictly related to the paper, because of the increasing adoption of cosmic-ray, as one of the few methods for measuring / monitoring soil water. Hence, introducing the general specificities of FDEM - ERT, cosmic ray, and soil sensors is relevant in our opinion, also considering the agrogeophysics special issues.

- L73-74 I would mention that ERT and FDEM measure other physical parameter than the resisitvity.

Sure, that’s clearly the case, thank you. The sentence now reads as follows (L74).

ERT and FDEM primarily measure the electrical resistivity of the subsurface, while also being sensitive to its capacitive and inductive response (Rubin and Hubbard, 2005).

- L171 ``non falsified''. I enjoyed reading this. Thanks.

Thank you for taking the time to read this and for your feedback.

- Materials and methods. L174-184. Please can you add that there is not slope (or very minor) in your orchad ?

Done, this sentence was added (L178). *The topography of the farm is flat.*

- Line 182-184, for your +/- this is not uncertainties nor sigma, this is the range of your data if I understood correctly, please state it.

Thank you. We stated that (L186)

the indicated ranges are standard deviations and reflect the real variability of the trees, i.e., not the uncertainty of the measurements.

as correctly pointed out by the comment.

- Line 197, state that METER is a brand, maybe METER, GMBH/LTD or something similar, to avoir confusion.

Yes, we replaced Meter with METER Group to avoid the possible confusion indicated by the comment.

- Line 214-217. Congrats on doing the measurements in such hot conditions.

Thank you for the understanding, likely based on significant fieldwork experience.

- Line 224. How did you manage to keep the instrument height at 0.1 m, and what is the influence on having a higher or lower value on your data ?

Grass coverage was very negligible, because of the managed environment, and specifically also thanks to the hot and dry conditions. This surely is the key aspect, as grass can hinder the measurement stability (and thus quality) when surveying at low heights, as correctly implied in the comment. Then, the same experienced person (co-author Ulrike Werban) ran all the mini-explorer surveys, avoiding the otherwise possible systematic height changes (although the used telescopic handle would help with this). Finally, the instrument's high sampling rate, and the following (described) smoothing and interpolations would address possible residual height effects. Therefore, we would exclude significant effects associated with height changes. This is also reflected by the absence of trends and/or particular oscillations in FDEM maps in our opinion.

- Line 238 would remove QGis from this line and write it further, because we get the impression that Qgis helped for the inversion.

Done.

- Line 241-243 The GEM-2 ``[....] factory conversion''. Can you add just one sentence to explain it a bit more especially concerning the factory calibration ?

Done. The following sentence was added (L247).

The latter Mini-Explorer adjustment starts by removing (i.e., divide by) the numerical factor defined by the manufacturer for the default conversion from quadrature to apparent conductivities, and then use the quadrature values in EMagPy to numerically calculate the apparent conductivities, with the correct surveying parameters.

- Line 245 ``processed in QGIS.'' I would add ``for positionning.'' just

Done. The following clarification was added (L253).

, starting from the correct positioning.

- Line 249 What type of distribution are your or were you expecting ?

No particular expectations, a part from some correlations with the field geometries (visible and discussed later) and general data instability that could suggest noise or surveying issues.

- Line 265 GPR should be GPS I think.

Yes, exactly. Done.

- Line 270-271, ``atan2 function'', you may need to cite numpy

Yes, done.

- Line 321, ``perpendicular to the tree line'' maybe add : ``(represented by the black rectangle)''.

While the perpendicular direction is common to both model domain and black rectangle, the model domain is not specifically located in the field, it only reproduces the general geometry (plant spacing, etc., as described). Therefore, no changes were made here.

- Line 329, ``Feddes parameters''. Could you describe them very very rapidly in the intro, when you introduce RWU ?

We found the description provided in the successive sentences to be adequate, as it lists the parameters, briefly their meaning, and associated values (with differences between grass and trees). We preferred to keep the description here, so that values and names-descriptions are all together. In general we find the provided names sufficiently self explanatory for the expected reader (e.g., deficit point , wilting point , and anaerobiosis point). Nonetheless, we made sure correct and sufficient references were provided.

- Line 339, compare the water volume input in the model with real values.

Yes, we agree that the same water inputs have to be used in order to keep the model simulations realistic, and then compare simulated and measured VWC trends. To this end, the field water inputs were both calculated from the known characteristics of the irrigation system and verified (periodically choosing and testing some drippers, see paragraph from line 188). The sentence now reads as follows (L345).

The irrigation was modeled by distributing the known water inputs over two stripes of 1 m width along the two tree rows. This resulted in a water input of 1.22 × 10−6 m s−1 over the five hours of irrigation, i.e., reproducing both flow rates and schedule of the irrigation system described above.

- Line 343, Mualem-van Genuchtenm since you are using the van genuchten model, it implies the mualem model for hydraulic conductivity.

Yes. We changed it into *Mualem-van Genuchten*.

This was done also for previous and successive mentions of the van Genuchten model. Citations of Mualem and van Genuchten were also added to reflect these changes.

van Genuchten, M.Th., 1980. A Closed-form Equation for Predicting the Hydraulic Conductivity of Unsaturated Soils1. Soil Science Society of America Journal 44, 892. https://doi.org/10.2136/sssaj1980.03615995004400050002x

Mualem, Y., 1976. A new model for predicting the hydraulic conductivity of unsaturated porous media. Water Resources Research 12, 513–522. https://doi.org/10.1029/wr012i003p00513

- Line 441-443. I did not get what you did with the extract values above 40, since your limit since to be 45 (by the way can you redo the colorbar with 45 written plainly).

Yes, the maximum values are around 45 ohm m, with extraction we mean that the parts with resistivity values above 40 ohm m are maintained to show their distribution and 3D shapes. We used extract because this is what we found in Paraview and Pyvista,

Yes, the format of the maximum and minimum values of the colorbar was changed to avoid the scientific notation, surely the suggested integer notation is cleaner here, thank you. The actual values remained unchanged, i.e., 10 and 45 ohm m.

- Line 451. Restate FC and WP and maybe restate that FC is -0.3 kPa and WP is -15 kPa, so you can write the standard deviation with units.

Thank you, done. The sentence now reads as follows (L466).

The laboratory water retention measurements that were performed on the eight soil samples yielded a VWC of 0.4 at Field Capacity (FC, −0.3 kPa) and 0.28 at Wilting Point (WP, −15 kPa). The standard deviations were 0.015 kPa at FC and 0.012 kPa at WP, which suggests relatively homogeneous soil characteristics.

- Line 455-460 I am not certain the gamma-ray survey brings more info than a granulo+Xray driffrac, but if you think it brings something to your study, why not. I still believe that a granulo curve would give more info for retention curve and other hydro parameters. I probably have missed something.

Yes, considering the homogeneous soil conditions, the gamma-ray agree with the granulometric information (soil type) and associated homogeneity. X-ray mineralogy information would also be very helpful, we agree this would be true in general. That said, gamma-ray was used as a faster solution to map possible heterogeneity in the field (e.g., clay and organic matter), in this sense it likely has its place in agrogeophysics and was still helpful in excluding such variations. Thank you for the general feedback.

- Line 467-468. You mentionned soil heat flux with the letter H, I think you meant G ?

Yes, thank you for noticing this, we clearly meant to use G, in line with the rest of the manuscript and common literature notation. We replace H with G.

Line 505 : Mulaem-van Genuchten

Done, citations were added before (see also above comment).

Line 525 : What is the distance to your flux tower ?

It is within the same farm - property, at 500 m from the investigated area. This was clarified as follows (L540).

The potential ET was maintained homogeneous for all simulated days, reflecting the stable sunny conditions (Figure 8), and considering a maximum value of 7 mm d−1 , based on the available eddy covariance data (located within the farm property, at 500 m from the site).

Figure correction :

In general some of your labels omit A and B while you have figure A and B. Please, can you check them all ?

Labels were missing and added to figure 6.

Figure 1-B : remove outliers on the figure ? Very high spots in the south and one in the middle of the black rectangle.

Done, the outliers were removed. Thank you.

Figure 1-B, add something like `` background is an reconstructed RGB orthomosaic'' other wise background is Google map or other

The suggested clarification was added.

The background is a reconstructed RGB orthophoto mosaic.

Figure 3 , add ``the black rectangle is ...''

Thank you, the sentence was added.

The description was already present in figures 1 and 2, no changes were needed there.

Figure 3 : add A and B in the legend then split the description

Done.

Figure 5, How about making a figure of EM from CMD and EM from GEM2 as bi-variate plot for the same depth ?

While a quantitative ERT - FDEM comparison can be useful, and sometimes used for the calibration of the FDEM data, we find that this would not add much to this paper as the ranges already agree in terms of ranges and distribution, see fig. 6 and fig. 7 (see also first comment and associated changes). Also considering that the paper is also relatively long in our opinion (10 figures), we decided not to add the suggested figure. Thank you for the suggestion.

Figure 6, needs a bit of polishing, especially the axis name, the RMS or RRMS of the data/model and I would add tree picture symbolizing tree position, it will help the reader. I would also suggest to not cut the negative percentage difference, it will help assessing the quality of the data and inversion.

Done. Thank you very much for the suggestions.

1) Axis names were moved, the m indicates the meters.

2) The following sentence was added regarding the ERT inversion (L427).

The inversions converged to a chi-square value of one within three iterations, while also maintaining a relatively smooth model, with a regularization weight, lambda, of 80 (Rücker et al., 2017).

3) Small green rectangles were added to indicate the tree positions. We tried to add the trees, like in other figures, but the drawing was taking too much space in our opinion.

4) The range of the percentage difference was changed as requested, now it goes from -5 to 5 %.

Figure 8-A : change the ylabel, with unity. Add vertical arrows for the other infiltration

Done and done.

Figure 8-B : change ylabel with squared exponent. Why Rn is negative ?

Done, we replace W/m2 with W/m^2.

Longwave radiation emitted by the warm surface upward, as commonly reported in literature. This agrees with the strong daily radiation and thus heat accumulation.

Figure 9 : add a colorbar, even if it is conceptual.

Done.

Figure 10 - A : replace the position of the sensors VWC3-VZC4

The labels were corrected. Thank you.