# Response

**Article title:** Combining time-lapse electrical resistivity and self-potential methods to assess soil moisture dynamics in a forested catchment under the rainfall event

**Reference No:** hess-2023-190

**Authors:** Wenhang Jiang, Aimin Liao, Jiufu Liu, Guodong Liu

**Concerns：**

1.with interest I read your paper on "Combining time-lapse electrical resistivity and self-potential methods to assess soil moisture dynamics in a forested catchment under the rainfall event". Your paper presents an interesting case study that highlights the joint use of ERT and SP to detect and image flow pathways, which is almost impossible using conventional soil water sensors.

**Response:** Thank you very much for your very kind and professional comments.

2.The paper is well written and easy to follow and succinct, but in some parts I'm missing detail. This is the case, e.g., for the description of the timelapse inversion strategy, which is completely missing, and a more detailed description of the experimental setup. The repetition rate for the rainfall experiment is only mentioned in the results.

**Response:** Thank you very much.

"Therefore, the time-lapse inversion method was used between the monitor and base datasets. The base data is firstly inverted using the inversion method in Equation (3) to reconstruct the background resistivity model, i.e., the subsurface resistivity distribution. The subsequent monitor data sets (other times) are inverted using the time-lapse inversion method." This description of the timelapse inversion was also added at lines 232-237 in the revised manuscript.

To show the experimental setup more clearly, we have undertaken a comprehensive revision of Figure 2 (as below) in the revised manuscript, and provided a detailed description about soil temperature measurement as "The soil water content (SWC) and soil temperature was monitored using a set of TDR probes (TDR315H, Acclima, Inc., United States)." at lines 279-280 in the revised manuscript. "At depths and locations that didn't have a sensor, soil temperature was obtained by linear interpolation." We also added this statement at lines 285-286 in the revised manuscript.

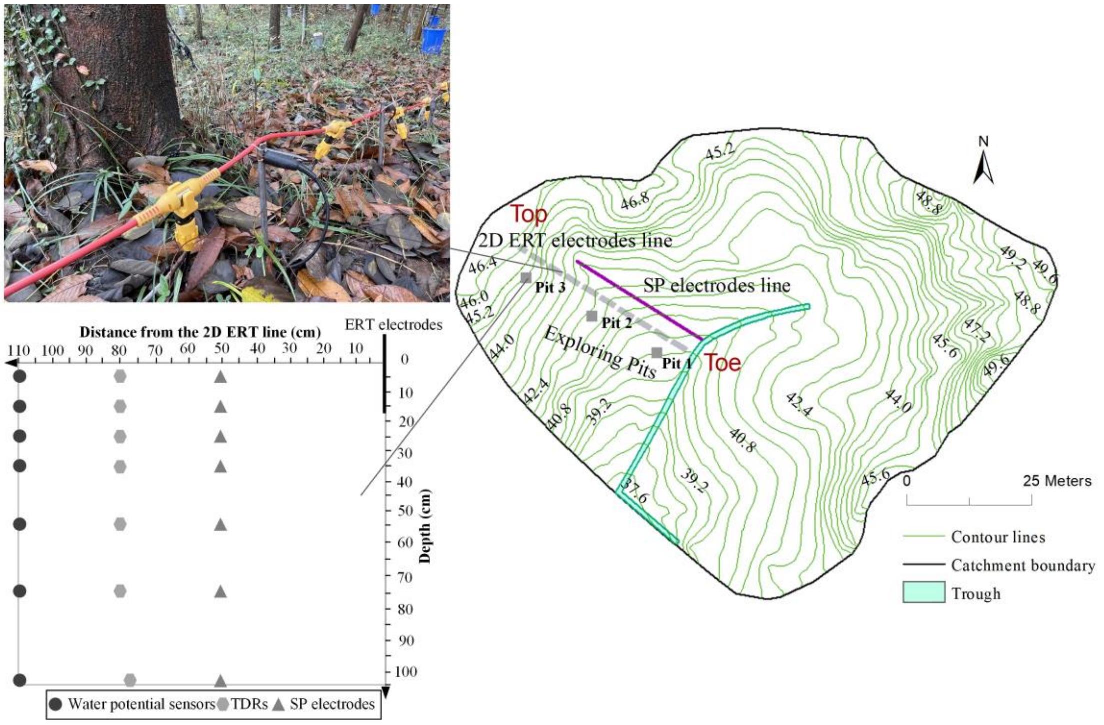



**Figure 2: Experimental setup of the slope at the Nandadish site, including the location of ERT electrodes, SP electrodes, TDRs and water potential sensors.**

For the repetition rate of the rainfall experiment, a description has been added to lines 165-166 in Section 2.2.1 of the revised manuscript, as below. "For rainfall events, ERT measurements were conducted at intervals of 1 to 3 hours."

3.Next to these rather minor comments, I am not fully convinced by the conclusions the authors have drawn from there data. You assign the spatially variable resistivity response solely to variations in vegetation cover and hence various root networks. Yet, while your soil analysis shows a reasonable homogeneous soil, the deeper resistivity may indicate a variation in bedrock composition. This is also indicated by the seismic velocities. Hence, I'm not fully convinced by the effect of the vegetation that is claimed to have been imaged, and I would suggest that the authors provide more info on the bedrock composition, which may be retrieved from deeper ERT and perhaps a detailed view of the SRT data.

**Response:** We gratefully appreciate your valuable suggestions. The interpretation that the resistivity and water content responses of spatial changes are only related to changes in vegetation cover and its root system is indeed inappropriate. We also found the error in depth calculation when we reanalyzed the water content distribution of depth profile at root location. The change of soil moisture at root locations with time and depth were corrected in the revised manuscript as follows. This content has also been modified in the revised manuscript.

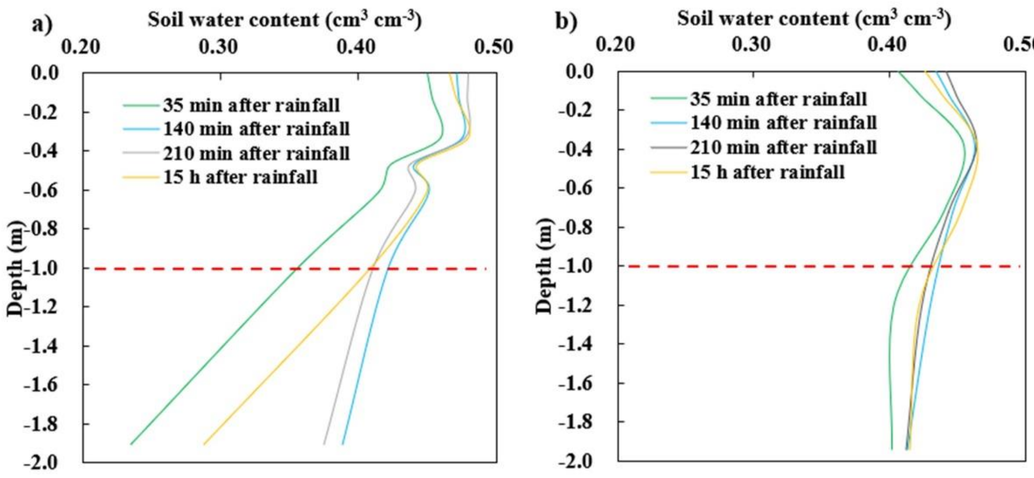



**Figure 11: Depth profiles with tree locations from electrical resistivity tomography measurements during and after rainfall, with a) for the Quercus acutissima Carruth and b) for the Broussonetia papyrifera.**

We mainly analyzed the spatial water change within the depth of 1.0 m. "At both tree sites, the soil water accumulated mainly in the shallow layer. For the Quercus acutissima Carruth, water accumulation was observed at a depth of 0.33 m, while for the Broussonetia papyrifera site, the water accumulated at 0.38 m, which corresponds to the predominant distribution range of the lateral root system. At the Quercus acutissima Carruth site, we also found a significant and abrupt decreasing change in water content at the depth of 0.45 m. This may occur at boundaries of coarse root and soil layers where root activity diverts new rainwater to replace the old and salty water (Cassiani et al., 2016)." These are also added to lines 540-547 in the revised manuscript. "As observed spatial water content changes cannot be attributed, in general, to root distribution alone, we further analyzed the change rate of soil water content at tree locations during rainfall and the results are shown in Figure 12. The water content of both tree sites increased during the rainfall; however, there was a significant disparity in the extent of this increase between the two locations. At the soil depth of 0.3-0.6 m, the two tree sites exhibited a relatively minimal rate of water content increase, perhaps due to the distribution of their fine roots here that water uptake by these roots (Cassiani et al., 2016) may lead to limited water change in the soil-root region. At the Broussonetia papyrifera site, the soil water content exhibited a relatively smaller increment compared to that observed at the location of Quercus acutissima Carruth. This discrepancy was particularly pronounced at greater depths and may be attributed to the rainwater flow along the Quercus acutissima Carruth's coarse roots present at those depths. In contrast, Broussonetia papyrifera's shallower coarse roots do not serve as effective drainage channels for facilitating rapid increases in water content at deeper layers." These are also added to lines 553-565 in the revised manuscript.

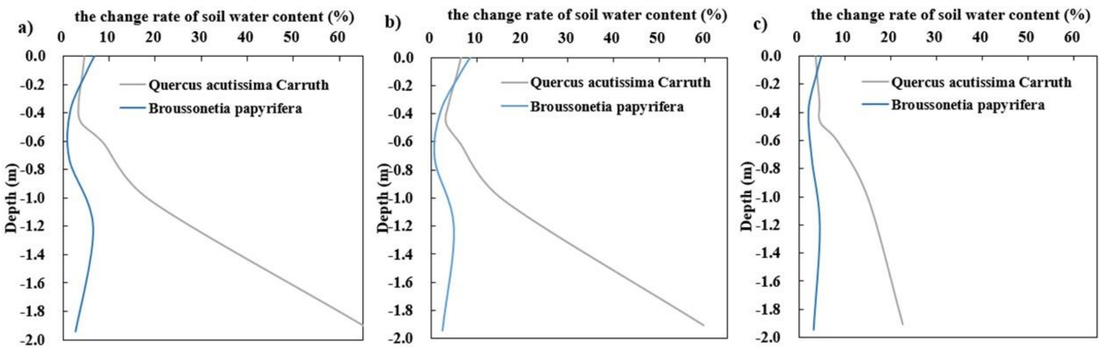
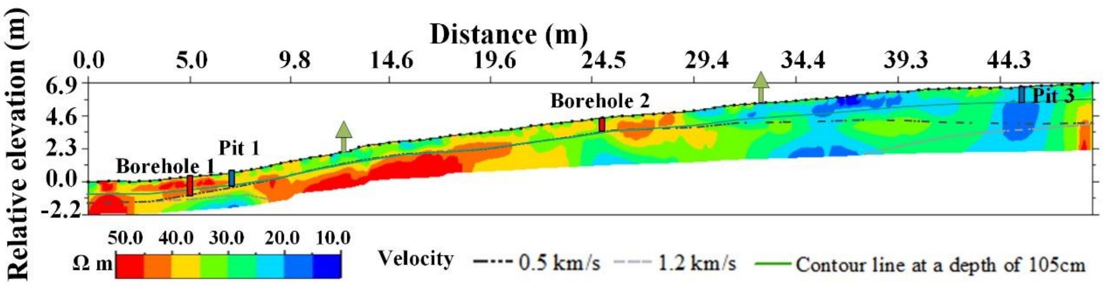



**Figure 12: The change rate of soil water content with respect to the background at depths, at a) 140 min after rainfall, b) 210 min after rainfall, and c) 15 h after rainfall.**

Because seismic velocity and resistivity are sensitive to different subsurface physical properties, comparing them can enhance understanding of subsurface structure and water content distribution. The figure below puts the background resistivity together with the seismic wave results. We can see that there is a pronounced lateral change in the resistivity (using Dipole-Dipole configuration) of the profile above the 0.5 km $s^{-1}$ seismic rate contour. The lower resistivity at 30 to 49.5 m and the higher resistivity at 0 to 29 m in the subsurface were detected. This phenomenon can be attributed to changes in the degree of saturation of pores (water content difference) or possibly variations in clay distribution. Combined with the analysis results of soil properties in pit 1 and pit 3, which indicate that the clay content are both above 10% at 105cm depth and soil texture are relatively uniform in these positon. Therefore, this variation should be caused by the change of water content. Two boreholes were at section 5 m and 25 m (Boreholes 1 and 2) with a maximum drilling depth of 1.6 m at the 5 m position and 1.0 m at the 25 m position. This is consistent with the 0.5 km $s^{-1}$ contour line position, further verifying that there was hard soil or rock below the 0.5 km $s^{-1}$ contour line. Whether the resistivity change below the sampling depth of 105 cm is due to lithology change or moisture change has not been verified in this paper. We fully agree with your statement that the resistivity change in a given space is influenced by multiple factors. However, the short time (hours and days) variation of soil or lithology at the same location is practically negligible. Under this assumption, our main focus lies in analyzing the temporal evolution of resistivity and attributing it to the influence of rainfall water.




**Background ERT Inversion results and the velocity contours within the resistivity space.**

**In the attached you will find some more detailed comments.**

**Response:** Thank you very much.

1.I wouldn't say that roots and canopy contribute to flow, but they provide some control on it.

**Response:** Thank you very much. We have modified the inappropriate expression "In addition, subsurface structure, vegetation canopies, and highly distributed roots **can be the significant contributors to the flow**, leading to heterogeneity in soil moisture distribution and associated dynamics" to "In addition, subsurface structure, vegetation canopies, and highly distributed roots **play a significant role in controlling the flow**, leading to heterogeneity in soil moisture distribution and associated dynamics" at line 43 on page 3 in the revised manuscript.

2. I don't think that this should be past tense.

**Response:** Thank you for reminding us of this inappropriate expression. We have changed the past tense into the present tense at line 57 on page 3 in the revised manuscript as below. "These point data or low sampling density **prevent** a full description of the dynamics of hydrological processes and structures with a high spatial resolution."

3. Delete "s" and "the"

**Response:** Thank you very much. We have modified at lines 68-69 in the revised manuscript as below. "The SP method has been found to be a complementary **method** in characterizing subsurface water flow. Richards et al. (2010) **used ERT and SP** and identified nine preferential flow paths in faults"

4. Just as a note, not focusing on field studies there is a considerable amount of papers on the resolution properties and optimization of ERT resolution. While these don't focus on the application of petrophysical relationships, they study in detail the resolving properties of various measurement configurations.

**Response:** Thanks for your valuable comment. Some papers were cited to highlight the research on resolution properties of various measurement configurations, which were not specifically focused on field studies. Therefore, we changed the "Some papers dealt with the depth of investigation (Oldenburg and Li, 1999; Robinson et al., 2012; Carey et al., 2019), and some with the sensitivity (Holbrook et al., 2014) of the resistivity image resulting from different electrode arrays. Ain-Lhout et al. (2016) focused on the ability to recognize resistivity differences in different media, and concluded that the Wenner configuration seems to be the most appropriate as it can differentiate the resistivities of the soil, soil moisture, and argan roots. These studies reported different perspectives to decide electrode arrays for more reliable and representative ERT measurements, and no similar study evaluated the ERT configuration performance by $R^2$ of the petrophysical relationship between resistivity and water content, especially in the forested site" to "**There is a considerable amount of papers on the resolution properties and optimization of ERT resolution (Dahlin and Zhou, 2004; Loke et al., 2013). For field studies, some** papers dealt with the depth of investigation (Oldenburg and Li, 1999; Robinson et al., 2012; Carey et al., 2019), and some with the sensitivity ( Holbrook et al., 2014) of the resistivity image resulting from different electrode arrays. Ain-Lhout et al. (2016) focused on the ability to recognize resistivity differences in different media, and concluded that the Wenner configuration seems to be the most appropriate as it can differentiate the resistivities of the soil, soil moisture, and argan roots. These studies reported different perspectives to decide electrode arrays for more reliable and representative ERT measurements, and no similar study evaluated the ERT configuration performance by $R^2$ of the petrophysical relationship between resistivity and water content, especially in the forested site" at lines 78-80 in the revised manuscript as below.

**Added references:**

Dahlin, T. and Zhou, B.: A numerical comparison of 2D resistivity imaging with 10 electrode arrays, Geophysical Prospecting, 52, 379–398, https://doi.org/10.1111/j.1365-2478.2004.00423.x, 2004.

Loke, M. H., Chambers, J. E., Rucker, D. F., Kuras, O., and Wilkinson, P. B.: Recent developments in the direct-current geoelectrical imaging method, Journal of Applied Geophysics, 95, 135–156, https://doi.org/10.1016/j.jappgeo.2013.02.017, 2013.

5. "combined" may be more appropriate

**Response:** Thank you. We have changed "coupled" to "combined" at line 89 in the revised manuscript. Therefore, the complete sentence is formulated as "Here, two-dimensional ERT surveys were **combined** with the SP method to characterize the infiltration process in response to rainfall at a high resolution."

6. misspelling at line 86

**Response:** Thank you. We have changed "deepth" to "depth" at line 92 in the revised manuscript.

7. What is the elevation, and the likely temperature variation? I'm asking because this may determine whether the site and ecosystem are water-limited or not.

**Response:** Thank you. "The average elevation of the Nandadish catchment is from 37 to 50 m." We also added this statement at line 115 in the revised manuscript. "with an average annual rainfall of 1008 mm and annual temperature of 15.4°C (from 1951 to 2016)." "Historical records indicate the occurrence of extreme temperatures, with the highest of 41.5°C in 1966 and the lowest of -23.8°C in 1955." We also added these statement at lines 117-120 in the revised manuscript.

8. This means that you are controling surface flow into your study domain. What is the control on subsurface flow?

**Response:** We are sorry for this confusion. The expression "Its perimeter is separated from the surrounding area by concrete boundary walls and acts as a watershed" aims to present surface flow and subsurface flow control. We modified this statement at lines 128-130 in the revised manuscript as below. "Concrete boundary walls are built around the catchment from the surface to the bedrock, thus controlling both surface and subsurface flow."

9. What does this mean specifically in terms of repetition intervals?

**Response:** Thank you very much. We have changed "The measurements were intensified during rainy periods to better represent the rainfall infiltration processes in the subsurface." to "For rainfall event, ERT measurements were conducted at intervals of 1 to 3 hours." at lines 165-166 in the revised manuscript.

10. What do you mean by that?

**Response:** Thank you very much. The explanation of the sentence "Meanwhile, to avoid anomalies in the resistance measurements during drought caused by poor contact (dry soils can produce a **vacuum** at the soil-root interface), a little water was added to slightly wet the soil around the electrodes" is as follows. When the soil is dry, the ERT electrode may come into contact with air if there is insufficient contact between the soil and the electrode, leading to an abnormal increase in the contact resistance. To make our expression clearer, we changed the expression as "Meanwhile, to avoid anomalies in the contact resistance during drought and further improve the data signal-to-noise ratio, a little salt water was added to slightly wet the soil around the electrodes" at line 176-178 in the revised manuscript.

11. You are using an inversion, hence I would not call it the "true" resistivity distribution.

**Response:** Thank you very much. We have removed the "true" at line 199 in the revised manuscript. Therefore, the sentence was changed to "The spatial distribution of resistivity can be determined by inversion of the subsurface apparent resistivity within a specified error level and appropriate inversion model constraints".

12. I don't think that this is correct.

**Response:** Thank you. The express of $[\boldsymbol{d}-f(\boldsymbol{m})]^T$ is the transpose of $[\boldsymbol{d}-f(\boldsymbol{m})]$, $[\boldsymbol{d}-f(\boldsymbol{m})]^T[\boldsymbol{d}-f(\boldsymbol{m})]=\|\boldsymbol{d}-f(\boldsymbol{m})\|^2$. This has been used in many literatures cited in this paper (deGroot-Hedlin et al., 1990; Nimmer et al., 2007; AGI 2009; Garré et al., 2011; Robinson et al., 2012; Beff et al., 2013). To avoid misunderstanding caused by this improper expression, we deleted the sentence "$T$ is the matrix transfer" at line 210 in the revised manuscript.

13.I don't think that this is an appropriate reference here.

**Response:** Thank you very much. The reference is cited here because it also employs the root mean square (RMS) as an index for evaluating the performance of ERT inversion and provides the calculation formula. For clarity, the position of this reference has been adjusted, resulting in the modification of the expression to "The root mean square (RMS) **(Tsai et al., 2021)** in each survey was calculated to find a resistivity model whose response best fits the measured data" at line 223 in the revised manuscript.

14. I'm not sure what you mean by that. The resistivity is on a first order determined by the soil composition, and then by things like water content and temperature. How and why would you try to minimize the effect of the soil composition?

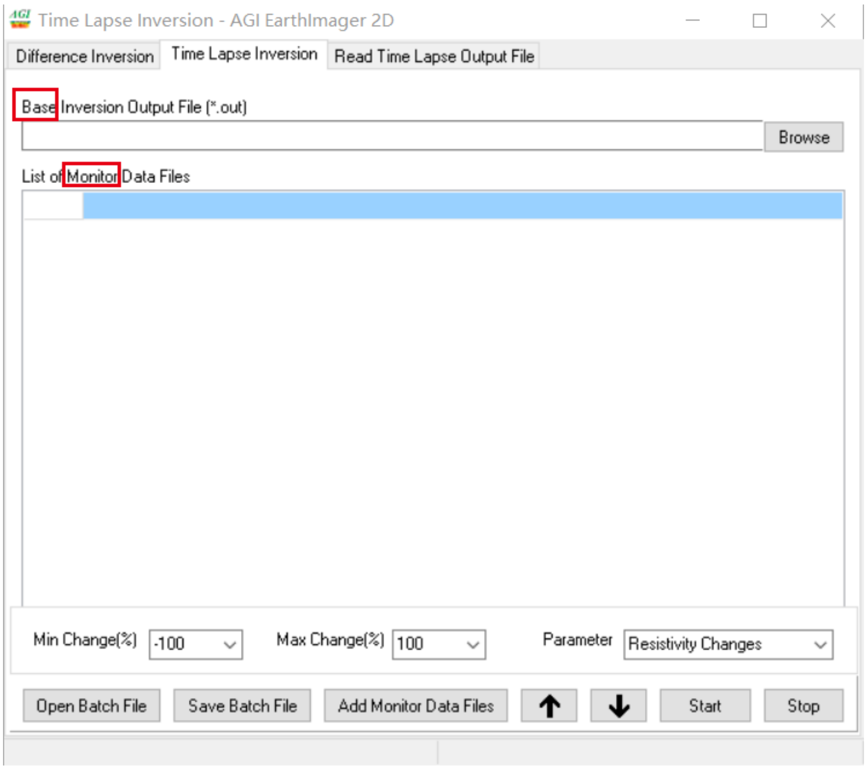
**Response:** We are sorry for this confusion. As you mentioned, the factors that affect the resistivity include soil composition, temperature, water content, and so on.

Therefore, we changed the "The effect of soil characteristics, such as clay content, on the measured electrical resistivity should be minimized by accounting for differences in resistivity (Srayeddin and Doussan, 2009). To better identify the changes of wetting peaks due to rainfall, we need to select the base (pre-rainfall) resistivity dataset, which can be regarded as an a-priori resistivity model. The time-lapse inversion method was used to invert the difference between the monitor and base datasets." **to** "To clarify the impact of water content on resistivity, it is necessary to eliminate influences such as soil and temperature. For temperature, a correction method is employed in Equation (2) (Equation (1) in the original manuscript). For soil, the variability of soil composition can be restricted by the use of time-lapse measurements (Srayeddin and Doussan, 2009; Vanella et al., 2018), assuming that significant changes in soil composition do not occur within a short time (e.g., hours or days) during the rainfall process. Therefore, the time-lapse inversion method was used between the monitor and base datasets." at lines 227-234 in the revised manuscript.

15. I'm not familiar with AGIs code. How is the timelapse inversion set up? Is it a reference inversion, difference inversion, or a true timelapse inversion?

**Response:** Thank you very much. The true time-lapse inversion was utilized in this paper. "The base data is firstly inverted using the inversion method in Equation (3) to reconstruct the background resistivity model, i.e., the subsurface resistivity distribution. The subsequent monitor data sets (other times) are inverted using the time-lapse inversion method." We also added these statement at lines 235-237 in the revised manuscript. These content also introduced on page 134 of the instruction manual for EarthImager 2D (version 2.4.0) (uploaded as an supplement).

The following shows an interface for time-lapse inversion in the 2D inversion software EarthImager.




16. How did you perform the temperature correction at depths and locations where you didn't have a sensor?

**Response:** Thank you. "At depths and locations where didn't have a sensor, soil temperature was obtained by linear interpolation." We also added this statement at lines 285-286 in the revised manuscript. A linear relationship between soil temperature (averaged at the same depth of Pit 1 and Pit 3) and depth was established. Therefore, it is possible to interpolate the temperatures at various positions and depths.

17. Given that the SRT data is only a small detail here, I wonder whether this lengthy description is needed. On the other hand, as you see from my other comments, I'm not fully convinced that variation in the resistivity dynamics can be solely explained by variations in SWC. Perhaps showing the tomogram may provide more evidence that bedrock variations have no impact at the SWC variations.

**Response:** We appreciate your suggestion. To describe the acquisition and processing of seismic wave data as clearly as possible, we have reduced the description of textbook material in the seismic method. The modified content are as follows: "The seismic refraction method was used to create the primary p-wave velocity and obtain the thickness information of weathering layers and the position of the fractured bedrock.

The seismic refraction data were recorded between the ERT and SP section using MCSEIS-SX48 (OYO Corporation, Japan) with 24 channel seismographs and 28 Hz vertical component geophones spaced at 2.0 m. The shot was a 5 kg sledgehammer that struck a stainless-steel circular plate with a diameter of 10 cm and a thickness of 4 cm. The first arrival times of the P wave were picked manually on all traces. Based on a 2D layered velocity, the inversion was performed until the RMS error between the observed and modeled travel times reached 5 %. The inversion results are smooth boundaries with different velocity values. The 0.5 km $s^{-1}$ contour on all final velocity models was used to delineate the transition between loose, highly porous media and the underlying saprolite, and the 1.2 km $s^{-1}$ contour represents the transition between the saprolite and fractured bedrock (Holbrook et al., 2014; Carey et al., 2019)." at lines 291-305 in the revised manuscript.

We fully agree with you. Bedrock variations certainly affect water content and water flow in the subsurface. This phenomenon is evident in our discussion of the preferential flow occurring at the interface between soil and fractured bedrock during rainfall in Figure 7. The effect of this change is not further discussed and analyzed in this paper because our main focus is on the rate of resistivity change over a short period (hours and days) during rainfall, when the variation of soil or lithology at the same location is practically negligible.

18. Is this shown somewhere and if so, what are the reasons for the variability?

**Response:** Thank you. "As shown in Figure 3c, soil temperature varied significantly near the surface." This expression is also added at line 329 in the revised manuscript.

We also added an explanation for this change at lines 330-333 in the revised manuscript as below. "The greater variability of surface temperature may be due to external meteorological influences, such as solar radiation and air temperature, while the magnitude of soil temperature change decreases with depth may be attributed to reduced interference from these external meteorological changes."

19. Is it really just a variation in water content, or could there also be a change in soil properties?

**Response:** Thank you very much for reminding us of the inappropriate expression here.

We aimed to depict the conditions within a shallow soil layer (above the 0.5 km $s^{-1}$ seismic wave velocity contour). The characteristics beneath this contour, including lithology, water content, and other factors, may exert an effect on the water content. Therefore, we removed this inappropriate sentence of "The lower resistivity at 30 to 49.5 m and the higher resistivity at 0 to 29 m in the subsurface were detected, indicating the initial higher and lower water content, respectively" at lines 348-349 in the revised manuscript.

20. What do you mean by that? Is what you show the differencen in resistivity with regards to a baseline measurement? To me it just looks like a resistivity distribution, no difference.

**Response:** Thank you very much. The presented data in Figure 4 were not the variation among different ERT measurements. We have revised this inappropriate expression from "the differenced resistivity model processed before, during, and after rainfall "to "the resistivity distribution before, during, and after rainfall" at lines 354-355 in the revised manuscript.

21. This is very shallow, how did you determine the depth of investigation? Which wenner and dipole dipole measurements did you take?

**Response:** Thank you very much. "The depth of investigation for ERT was determined according to Edwards, (1977).

$$z = \partial \times a \tag{1}$$

where $a$ is the maximum electrode distance. $\partial$ is the depth coefficient determined by the maximum distance factor $n$. $\partial$ is 1.476 when n = 5."

The above was added to lines 180-184 in the revised manuscript. Since our study focuses on the dynamic changes of moisture in the shallow soil layer, we have chosen small values for both the maximum electrode distance ($a$) and the maximum distance factor ($n$) when conducting ERT measurements during rainfall. "2.2 m is the depth of investigation, calculated by Equation (1) taking three times the electrode distance for $a$, $a = 3 \times 0.5 = 1.5$ m, and $n = 5$. Structures below this depth cannot be used for geological interpretation." These statement were added at lines 358-360 in the revised manuscript. The depth coefficient for calculation of investigation depth is as follows, which is extracted from the article of Edward (1977).

**Table 1. Empirically determined dipole-dipole depth coefficients, and comparison with two versions of theoretical effective depth.***

| $n$ | (1) $c_n = \frac{z_e}{a}$ | (2) $c'_n = \frac{z_e}{L'}$ | (3) $\frac{z_{max}}{a}$ | (4) Col. (1), normalized to Col. (3) | (5) $\frac{z_{med}}{a}$ | (6) Col. (1), normalized to Col. (5) | (7) $\frac{z_{med}}{L'}$ |
|---|---|---|---|---|---|---|---|
| 1 | 0.240 | 0.840 | 0.298 | 0.323 | 0.416 | 0.415 | 0.208 |
| 2 | 0.403 | 0.940 | 0.525 | 0.539 | 0.697 | 0.697 | 0.232 |
| 3 | 0.556 | 0.973 | 0.735 | 0.744 | 0.962 | 0.962 | 0.240 |
| 4 | 0.705 | 0.987 | 0.939 | 0.943 | 1.220 | 1.220 | 0.244 |
| 5 | 0.853 | 0.996 | 1.139 | 1.143 | 1.476 | 1.476 | 0.246 |
| 6 | 1.000 | 1.000 | 1.338 | 1.338 | 1.730 | 1.730 | 0.247 |

*Columns (1) and (2) are the empirical values, with arbitrary normalization. The values of Column (5) are accepted for the absolute coefficients $C_n = z_e/a$ and used in the modified pseudosections.

The Dipole-Dipole configuration was adopted in Section 3.2.1, which is supplemented at lines 339-341 in the revised manuscript, as follows: "The mean inverted resistivity obtained for each ERT measurement (**using Dipole-Dipole configuration**) in Figure 4a presents a decreasing trend during rainfall events, from 25.8 to 22.0 Ω m."

**Added references:**


Edwards, L. S.: A modified pseudosection for resistivity and ip, Geophysics, 42, 1020–1036, https://doi.org/10.1190/1.1440762, 1977.


22. Is this change within the accuracy of the sensor?

**Response:** Thank you. This change of water content is within the accuracy of the TDR sensor, which is 0.001.

23. I don't understand these two sentences. First, you say that by adding water the resistivity can increase, but in the second sentence you suggest that these are artifacts. So what is it? I would agree that this is most likely an inversion artifact, which could be caused by the timelapse inversion strategy that is used. Also, there are a number of studies that look into this effect in particular and provide possible solutions, see, e.g., Loke MH, Wilkinson PB, Chambers JE, Uhlemann S, Dijkstra T, Dahlin T (2022) The use of asymmetric time constraints in 4-D ERT inversion. J Appl Geophys 197:104536. https://doi.org/10.1016/j.jappgeo.2022.104536

**Response:** Thank you. We are sorry for our careless mistakes. We have made revisions to our previous statement as below at lines 376-378 in the revised manuscript, changing "Note that the resistivity increases (red or yellow) during precipitation in Figure 5, which is **not an unreasonable** response to the adding of water in the subsurface." to

“Note that the resistivity increases (red or yellow) during precipitation in Figure 5, which is **an unreasonable** response to the adding of water in the subsurface.”

“Besides, there are a number of studies that look into inversion artifact effect in particular and provide possible solutions (Loke et al., 2022). Our research on inversion methods may be limited currently. Future investigations aimed to enhance the exploration of inversion methods to yield more compelling outcomes were needed.” We cited this article and added above content in the discussion section at line 501-505 in the revised manuscript.

24. That is not true, therea numerous other models that do account for surface conduction, like Waxman-Smits or Berg's effective medium theory.

**Response:** Thank you. It has been changed from “always” to “could” to make the statement more reasonable at line 388 in the revised manuscript. The sentence is thus modified: “Resistivity **could link** to water content through Archie’s law (Archie, 1942; Garré et al., 2011; Tsai et al., 2021) which assumes the clay content is negligible.”

25. How well were you able to collocate TDR sensor positions with ERT mesh cells?

**Response:** Thank you very much. The ERT inversion results were spatially interpolated (Inverse distance weighted) using ArcGIS, enabling the acquisition of resistivity data at corresponding TDR positions. “Electrical resistivity were generated for the TDR locations from spatially interpolated (Inverse distance weighted) using ArcGIS.” This sentence has been added to lines 394-395 in the revised manuscript.

26. I don't follow how your data suggests this difference.

**Response:** We appreciate your suggestion. From the seismic data, there does not seem to be a change in lithology, so it may be other factors, such as the presence of large pores in the saprolite or the root influence. At lines 413-416 in the revised manuscript, we re-analyzed and described the main reasons for the preferential flow channels here, as follows. “The occurrence of preferential flow on the right side may be attributed to the presence of higher soil porosity (Fan et al., 2015) in the saprolite or the existence of soil macropores surrounding coarse roots (Guo et al., 2020), which tended to retain more soil water during rainfall.”

27. While your soil analysis is showing reasonably homogeneous soil conditions, your

resistivity and seismic data suggest a change in lithology just below your sampling depth. You interpret this mostly as a change in initial SWC, but to me it looks more like a lithological change. Do you have any information on bedrock variability? Also, what is the rooting depth of these trees?

**Response:** Thank you very much. For the analysis of initial resistivity and water content, our statement is indeed inappropriate in terms of the space of the current moment, so we have deleted the expression content of "The lower resistivity at 30 to 49.5 m and the higher resistivity at 0 to 29 m in the subsurface were detected, indicating the initial higher and lower water content, respectively." at lines 348-349 in the revised manuscript. The statement of "high SWC occurred at the top of the hillslope, and decreased rapidly down the slope." was also deleted at line 409 in the revised manuscript.

The bedrock variability was provided by the seismic wave results in this paper. In addition, the verification results of boreholes at 5 m and 25 m of the section are consistent with the distribution of 0.5 km $s^{-1}$ seismic rate contour line position, where is the transition between loose, highly porous media and the underlying saprolite.

We are sorry for not being able to provide specific information about the root depth of the two trees researched in this paper, as they are still being measured in other experiments. The depth of roots can also be limited by the underground structure. Therefore, the root distribution of the same species of trees with similar DBH (Diameter at Breast Height) may also be different. In general, the root depth of trees in the study area ranged from 0.9 to 3.0 m, and the root depth of Quercus acutissima Carruth is greater than the Broussonetia papyrifera with similar DBH. In a recent experiment, we excavated a pit measuring 2.4 m in length, 50 cm in width, and 2.0 m in depth next to the trunk (40 cm away from the trunk) of another Quercus acutissima Carruth in the Nandadish catchment. The analysis of this root distribution revealed that most of the lateral roots were concentrated within the topmost 40 cm soil layer. The distribution of lateral roots of Broussonetia papyrifera is also approximately within this range. To make it more reasonable and clear, we have revised Figure 7 as below, adding the content of the change rate of water content of different monitor moment relative to the background. “In addition, spatiotemporal variability in moisture dynamics due to root was inferred from spatial variation in the change rate of SWC over time (Figure 7b).” This sentence was added at lines 416-417 in the revised manuscript. After further analysis, we changed “Unlike Broussonetia papyrifera with its shallow root system, Quercus acutissima Carruth with its deeper roots may **take longer to receive the available water flow in deeper soil layers** and have a more pronounced effect on soil moisture changes.” **to** “Unlike Broussonetia papyrifera with its relative shallow root system, Quercus acutissima Carruth with its deeper roots may **transport water flow along the roots to deeper soil layers** and have a more pronounced effect on soil moisture changes.” at lines 422-425 in the revised manuscript.

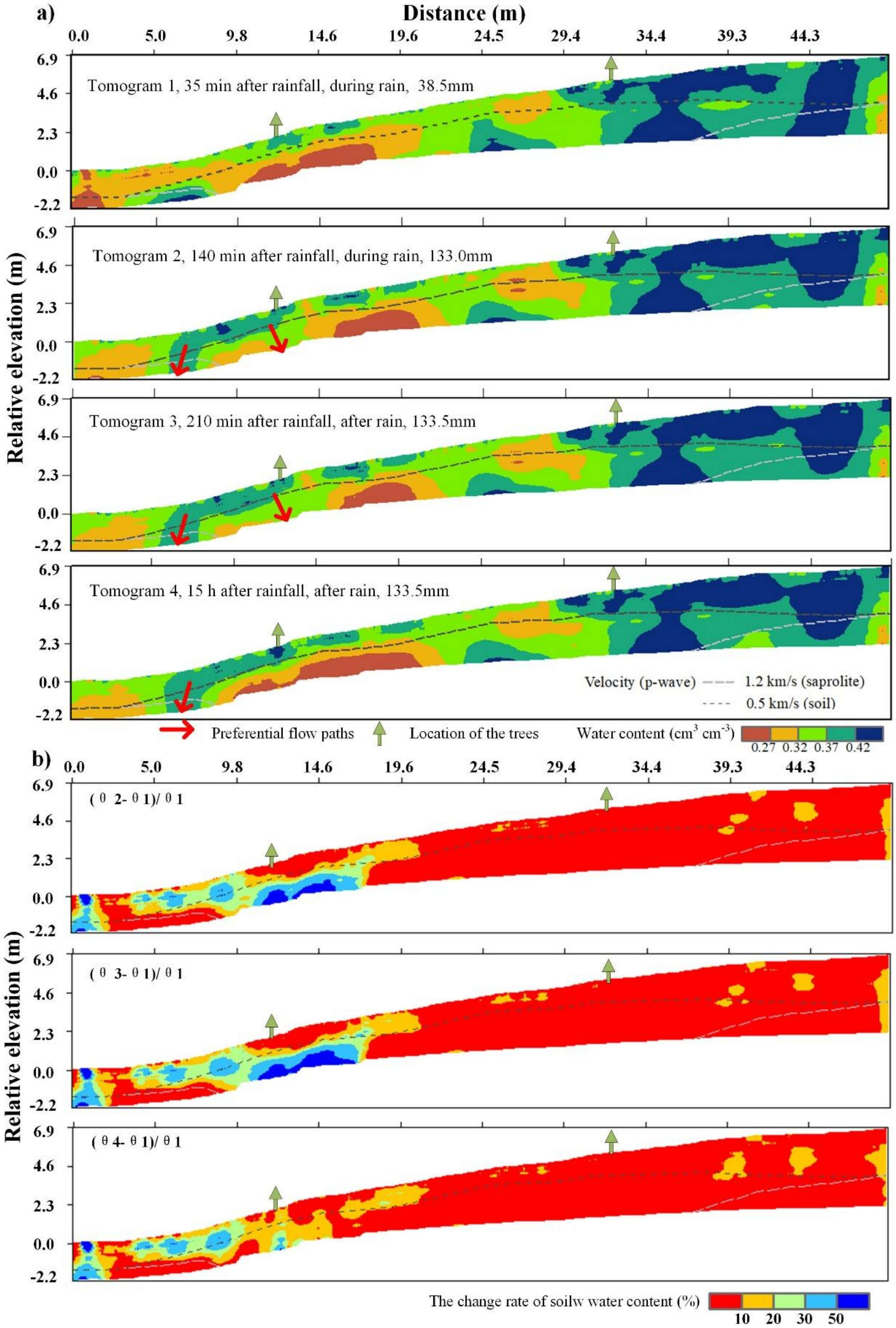



**Figure 7: 2D images of SWC variation and the change rate of SWC in the soil layer, with a) SWC variation estimated from the *ρ*–*θ* relationship relationship and b) the change rate of SWC. The green arrow on the left is the location of the Quercus acutissima Carruth and the right is the Broussonetia papyrifera. Two gray dashed lines represent the contour lines of the seismic wave velocity, the upper line shows a velocity of 0.5 km/s and the lower line shows a velocity of 1.2 km/s.**

28. Are these rapid responses in agreement with likely hydrologic conductivities at site?

**Response:** Thank you. The infiltration of rainfall results in a change in soil water content and an increase in electrical conductivity, which subsequently leads to an increase in self-potential (SP).

29. I agree that this is a good result. The way it is written sounds like you imply that this is a generally applicable relationship, yet it is likely site dependent as it depends on the soil properties.

**Response:** Thank you so much. The expression has been adjusted from "These data demonstrate the robustness of the proposed $\rho$–$\theta$ relationship in practical applications, allowing interpretations of $\rho$ in terms of hydrodynamic variations." to "These data demonstrate the robustness of the proposed **site-specific** $\rho$–$\theta$ relationship in practical applications, allowing interpretations of $\rho$ in terms of hydrodynamic variations **in the Nandadish catchment**." at lines 514-515 in the revised manuscript.

30. While the data does suggest a change between the two sites, it is unclear whether this is just a function of the root system.

**Response:** We are very grateful to you. Thank you for your questions about root depth and for questioning the root impact discussion here, which led us to discover the errors in data processing (depth processing).

The change of soil moisture at root location with time and depth was corrected as follows.

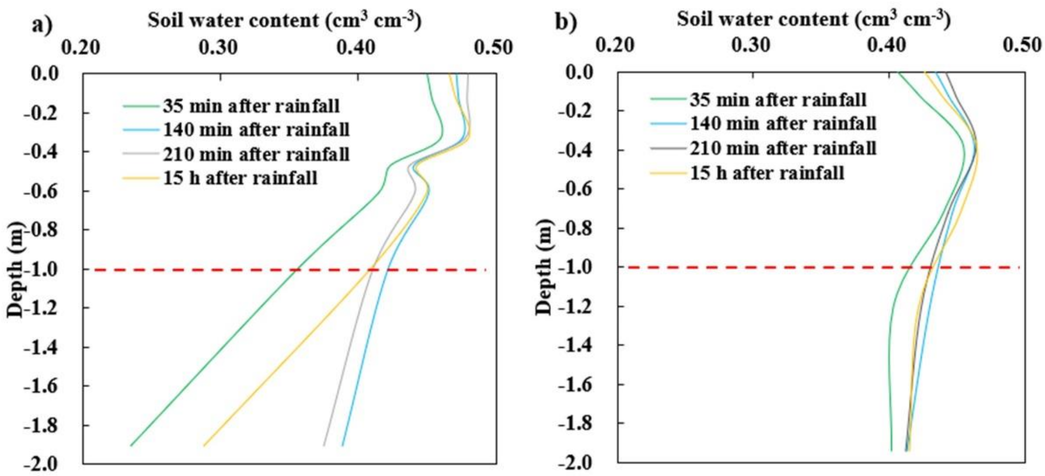


**Figure 11: Depth profiles with tree locations from electrical resistivity tomography measurements during and after rainfall, with a) for the Quercus acutissima Carruth and b) for the Broussonetia papyrifera.**

Spatiotemporal variability in moisture dynamics due to root was inferred from spatial variation in the change rate of SWC over time. In addition, we further analyzed the change rate of soil water content at tree locations during rainfall and added the results in Figure 12 (as below). There are two distinct phenomena: the water uptake by roots in the main root distribution area and the diversion of water by deeper coarse roots. There are two distinct phenomena: the water uptake by roots in the main root distribution area and the water transport along the deeper coarse roots.

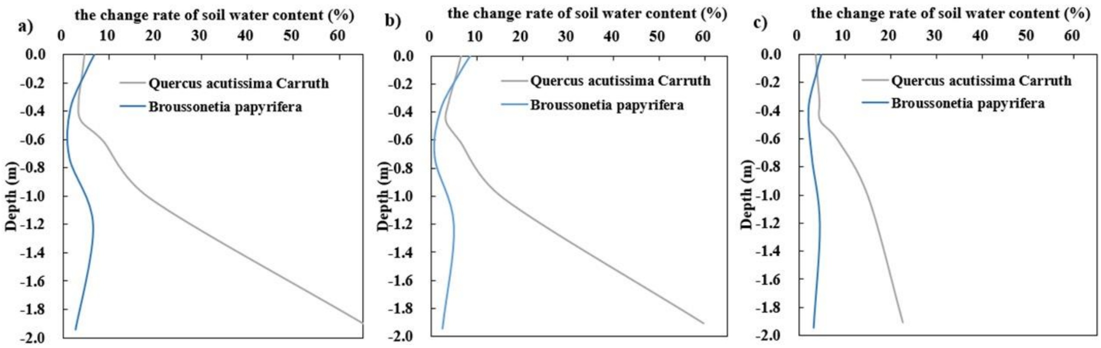



**Figure 12: The change rate of soil water content with respect to the background at depths, at a) 140 min after rainfall, b) 210 min after rainfall, and c） 15 h after rainfall.**

"Spatiotemporal variability in moisture dynamics due to substructure and roots was inferred from spatial variation in the change rate of SWC over time in this paper. Further studies are needed to separate soil structure and living plant root effects from water dynamics. For example, by combining 3-D surface and cross-hole ERT measurements with 3-D SP with short acquisition time in stem-centered or no-tree homogeneous soil layers to obtain a detailed interpretation of how root characteristics affect the soil water content dynamics." These content were added at lines 573-578 in the revised manuscript.

31. The rapid increase in SWC at depth does suggest some preferential flow, perhaps along the roots, but not necessarily that trees with deeper roots store and absorb water at depth.

**Response:** Thank you. We changed "Deep-rooted trees absorb and store water in deeper layers, resulting in significant abrupt changes in the water content of the deeper soil layers." to "Deep-rooted trees **allowed water to flow along the roots to deeper layers**, resulting in significant abrupt changes in the water content of the deeper soil layers." at lines 616-617 in the revised manuscript.

32. Data should be publically available.

**Response:** Thank you very much. The research data presented in this paper forms part of an ongoing research project conducted at the Chuzhou Scientific Hydrology Laboratory, which is currently not yet completed. Therefore, these data are not fully available at this stage. The data that support the findings of this study are available on request from the corresponding author.