Overall, I want to thank the authors for drafting this manuscript entitled "Application of geophysical tools for tree root studies in forest ecosystems in complex soils". The manuscript was well written and carefully developed. Having previously conducted similar root studies, I appreciate the long, meticulous hours collecting data and analyzing the results in root systems. Root systems represent a significant uncertainty in our understanding of ecosystems and representation of plant process in model frameworks.

The paper represents a continued interest in applying geophysical techniques to ecological questions. I think the authors do a great job at presenting the problem and application of GPR to this research question, however, they don't do a great job at highlighting potential limitations of the technique. From my experience with GPR, I have a hard time believing the authors were able to identify 0.6 diameter roots in rocky soils with a low frequency antenna (e.g., 500 MHz). Past studies we were able to see slightly smaller roots with significantly higher frequency (1500 MHz) antennas and working in ideal sandy soils. I also feel the authors could have explained how they classified "noise" and how they dealt with that aspect in their methods. Additionally, they didn't clarify if the signal they were detecting was a single root or a cluster. Finally, I worry they didn't provide enough details on the settings of the antenna (e.g., signal gain points), nor did they report any calibration of the antenna/method for their sites. All GPR practitioners will say that users must do some level of calibration to understand their site to adequately decipher their radiogram results. It's not clear if they have done this or just powered on the instrument and just used the factory default settings. I would recommend they provide some additional details before this is published. Once addressed, this paper will add to the growing knowledge of how to study root systems.

Introduction

The introduction was well written and presented a great overview of the topic. Unfortunately, the introduction lacked any mention of the real tradeoffs of using GPR in ecological issues. For example, there is a strong tradeoff between antenna frequency, resolution and depth. Higher frequency antennas (e.g., 2,000 and 1,500 MHz) provide greater ability to resolve smaller roots, but lack depth penetration (~0.5 meters), whereas a lower frequency antenna (e.g., 400 MHz), will provide increased depth, but only be able to detect larger root structures. Additionally, the authors don't adequately provide any details on the issues of overshadowing. Larger roots and rocks near the surface will inhibit the ability to discern high resolution details of smaller roots unless you have large transects where the (cone shaped)signal reflectance is interpreted from away, on top of, and past the target. I was disappointed the introduction lacked any clear description of the types of tree at the SSM or their typical root characteristics (e.g., tap root). Finally, the second objective "with the use of GPR, detecting roots of different diameter size classes growing at various depths in volcanic fractured rock" – Why just determine diameter? You could easily estimate root mass or architecture from this study and would likely be the most useful product for other studies/models to use (diameter is a poor indicator of age, mass, etc.).

Methods

Why were the plots circular? Circular data collection leads to some problems with interpreting such issues. There have been some companies (e.g., Tree Radar), that had to develop new methods to analyze tree trunk decay from GPR images collected around the trunk (in other words, in a linear transect, you can compare reflector intercepts, but in a circular scan pattern, you will have to deal with adjacent intercepts that will be dealing with different intercept angles at the edges). How did you account for this in your analysis? However, with a circular pattern, you could determine if there is any overshadowing of rocks or other roots.

Just using 0.1, 0.3, 0.5, 1.0 and 1.5 m transects – its unlikely you could detect small diameter (~0.6cm) roots with a 500 MHz antenna or a 900 MHz antenna with such large gaps (especially with the higher frequency antenna).

Did the soil sensors have any metal in them? If so, how did you deal with issues with signal attenuation?

On Page 5, when you talk about the principles of GPR, you could mention the resolution-depth-frequency tradeoff, but it might be better in the introduction.

What about air gaps? Wouldn't volcanic rock have a large number of "air bubble" gaps? How would you deal with issues associated with air gaps? From my experience, this causes change in the signal speed and can cause issues with your gain settings and therefore interpretation.

In page 6, section 2.5, to what depth?

How did you deal with the immediate ground reflection from the antenna? Were there any gaps (due to micro topography? If so how did you deal with this?

Page 6, line 26-31, over the 8 month sampling period, did you collect the ERT at the same time as the GPR? Since soil water content can change so rapidly in arid/semi arid regions, this would be important especially since changing moisture levels will impact your dielectric constant.

The manuscript makes no mention of site calibration for your equipment/method. From my experience, you need to calibrate GPR to the site conditions, especially with respect to signal gain points. It was unclear how many gain points were used and if they changes between plots (using the "automatic gain detection feature often isn't the best for mid to high resolution studies where you want to compare between plots.

Page 7, line 6 – how did you determine unwanted signal (noise)? Any criteria? This would be useful for readers to understand this step in case they wanted to use this methodology. I would suggest looking at or referencing methods listed in the book "Measuring Roots: An Updated Approach (Springer; Editor: S. Mancuso - ISBN 978-3-642-22067-8) or "Handbook of Agricultural Geophysics" (CRC Press; Editors: B> Allred, J. Daniels, M.R. Eshani - ISBN 9780849337284).

Did you do any ground truthing of this method? This would be important to know what depths you are really reaching with this method. Some past studies have inserted a metal reflector pate at a known depth (e.g., 50cm) to ensure proper calibration of the data. Otherwise you are just making assumptions of how deep you are penetrating. I realize you did dig up some surface roots for a comparison, but differences in the soil, air gaps, variations in soil moisture, etc. can speed up or retard the signal travel time resulting in changes in depth interpretations.

Why not use a higher frequency antenna like 1500 or 2000 MHz since most of your roots are in the upper 50 cm of the soil?

Soils and root systems are highly variable and roots tend to criss cross/overlap areas in the soil, how did you partition roots out in the radar where they overlap (or grow side by side) and not consider them as 1 root, rather than 2 smaller roots). With such a low freq. antenna your diameters could be smaller roots in a group, rather than one 2.5 cm diameter root.

Results

Page 8, line 26 – The authors suggest you could track elongation over time, but I doubt you could detect this with the sampling frequency and the reported diameter sizes, unless these are fast growing trees.

Its' unclear how the authors dealt with the shadowing from rock fragments and potential gaps or microsites of moisture in a crevice in their radiograms?

Page 9, line 11, its unclear what the authors mean by "spotted primarily" tree roots – what else was detected? this leaves some doubt in the detection analysis.

How did the authors tease out species specific information? (e.g., Page 9, lines 13-19)? Were these monoculture patches of species?

Page 9, line 5, wouldn't you need less than a meter for the 500 MHz to detect 0.6 cm roots? the 900 would likely detect this size range

Page 9, line 24-25 – could this finding be due to the differences in rooting strategies in Oaks and Pine species?

Page 10, line 1 – how long did the water infiltration signal last? Also, when was this objective/phenomena studied? This could matter because the transpiration and plant water demands could change the interpretation of the duration of the perturbation.

Discussion

Page 10, line 22-23, I agree with the dual frequency approach given differences in sites and a method I would use (the art of the method), but again, you need to do custom your method to your site (ground truthing/validation).

Table 1 – I doubt they are seeing 0.6 cm diameter roots with the lower frequency antennas in this rocky soil substrate. Past studies have achieve this only with 1500-2000 MHz antenna only in ideal soil settings (sandy soils)

Table 4 – the authors say "used for calibration" but don't really explain what they mean here? Also, It would be useful to show those regressions here.

Figure 1 – the rockiness of the soil, and possible air gaps, would make signal processing very difficult here, each plot would need to be calibrated.

Figure 2 – what's the age class of the trees?

Figure 3 – please italics the species names

Figure 4 – looks like you have some attenuation of the signal (e.g., where label "a" is located). Also what do the lowercase letters represent?