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Hydrology and Earth System Sciences
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Discussions

Interactive comment on "Quantitative high-resolution observations of soil water dynamics in a complicated architecture with time-lapse Ground-Penetrating Radar" *by* P. Klenk et al.

Anonymous Referee #1

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The manuscript presents results of a surface deployed ground penetrating radar survey conducted in a sand box having a known subsurface layering. Numerical hydrological modeling, observed water table, as well as full waveform calculation of the electromagnetic waves are used to understand the collected radargrams. In general, I think that the manuscript is well-written and the results are interesting. The manuscript could, however, benefit substantially from a few simple minor changes and further elaborations as the experimental set up is somewhat unclear to me. Below, I have listed three major issues that I think should be revised prior to publication.

First, I am very confused about the details of experiment 1. On page 12371 you write that 10 m3 of water is pumped into a well with a constant rate (23.4 cm/h) for 12 h. First of all, this is not in agreement with Figure 2, where the entire experiment time (including imbibition and drainage is approx. 12 hours). Second, if I divide 10 m3 over the 77.28 m2 area of the ASSESS site (18.4 m times 4.2 m) I get 0.129 m or 12.9 cm over the entire experiment time. How does this match up with the other data (23.4 cm/h) and the black line in Figure 2? Is it because one cannot expect that the water fills up the entire sand box, but only at a certain distance from the well? And why does the black curve on Figure 2 not increase at t=0 hours? The description of experiment 2 is also slightly unclear. I would suggest that you made a Figure 2a with experiment 1 and a Figure 2b with experiment 2. In these new figures you could include the timing of experimental changes with different background colors (i.e. one color for imbibition, drainage, infiltration, equilibrium time, etc.), but also you could include the timing of the collected radargrams presented in Figures 6 and 10.

Second, I think you should include more figures similar to Figure 7, where selected observed traces from the radargrams (Figures 6 and 10) could be presented showing the same behavior as the phenomenological studies in Figures 5 and 12. As an example, I find it difficult to see the three-featured wavelets and the distinct two-feature wavelet (observed on Page 12379, lines 1-2) in the small radargrams. Also the observation: ”the CFR signal split into two distinct two-featured wavelets” (observed on Page 12379, lines 10-11) could nicely be documented with a figure similar to Figure 7.

Third, given the accuracy in the estimation of the average soil water content, I think you should attempt to calculate your mass recovery.

Minor comments:

Title: I would change “with time-lapse Ground-penetrating Radar” to “using time-lapse Ground-penetrating Radar”

Page 12367, line 5: The reason soil moisture can be estimated is due to the large

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difference in permittivity between water and air, and not between water and soil.

Some of the following references could be included in the introduction:

Trinks et al., 2001. Monitoring water flow in the unsaturated zone using georadar. First Break 19:679–684.

Truss et al., 2007. Imaging rainfall drainage within the Miami oolithic limestone using high-resolution time-lapse ground-penetrating radar. Water Resour. Res. 43:W03405, doi:10.1029/2005WR004395.

Moysey, 2010. Hydrologic trajectories in transient ground-penetrating-radar reflection data. Geophysics 75(4): WA211-WA219

Haarder et al., 2011. Visualizing unsaturated flow phenomena using high-resolution reflection ground penetrating radar. Vadose Zone Journal 10, 84–97. doi:10.2136/vzj2009.0188

Mangel et al., 2012. Multi-offset ground-penetrating radar imaging of a lab-scale infiltration test. Hydrology and Earth System Sciences 16(11): 4009-4022

Page 12371, line 2: Is there a reference to this work?

Figure 1a and Figure 4: Is there not a mix-up in the labelling of the sand types? According to Figure 1a there is more sand C at the surface (depth=0m) than sand A, and in Figure 4 this is reversed.

Figure 6: What does the time t1 correspond to? (i.e. in subplot 5). Please add the exact time of each radargram. Page 12379, line 22 & Page 12380 line 20: Is there missing some text? Or what is meant by “14 . . . 16 m”?

Page 12379, lines 23-28: I am not sure I understand why you conclude that the reflection at 23 ns is porosity variation. Did you not state that the wavelet at 23 ns was caused by the CFR on lines 2-3? Is it not the same reflection you are discussing?

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Page 12381, line 1 & Page 12382, line 2: Again there is a strange "...".

Page 12382, line 18: How did you calculate 0.70?

Figure 10: I think it would be nice with the exact time of each radargrams in this figure. It could be supplemented by adding this information in Figure 2 as discussed above.

Figure 12: I think you should include a non-shifted travel time plot as well as the shifted travel time plot. And why does the time axis not start at 0 ns?

Interactive comment on Hydrol. Earth Syst. Sci. Discuss., 11, 12365, 2014.