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Hydrology and Earth System Sciences Discussions

Interactive comment on "A quality assessment of spatial TDR soil moisture measurements in homogenous and heterogeneous media with laboratory experiments" *by* T. Graeff et al.

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Firstly, we like to thank Reviewer I for the constructive comments that helped us improving the paper. The following lines explain how we met the recommendation in a revised manuscript.

Comments to the Authors

The paper is trying to indicate the applicability of "Spatial TDR" in strongly heterogeneous soils using detail indoor experiments. Although the paper totally was in a good organization, there were still several points needed to be paid more attention:

1. Considering the purpose of this paper, the focus should be on the test on the performance of spatial TDR in heterogeneous soils. In the other word, how good the soil moisture profile could be measured considering different heterogeneities. On this point, the experiments in the paper did not support enough that purpose. In section 4, only the experiment 4 considering the solid objects in the integration volume of coated TDR. Although this experiment indicated the influence of different solid objects, representing the heterogeneities, readers still can not completely understand exactly the effect of inserting solid objects. From Fig8., with different solid objects in the same soil wetness, the soil moisture profiles above the solid objects are more stable than below, which will cause a confusion, especially for the wet case. In this experiment, the column was in a stable initial wetness (0.3). It means that only the moisture content at the depth, where the object is inserted, would change. However, in Fig8.F, the soil moisture profiles also changed. Some are underestimated (iron, Boulder, brick), while others are overestimated (plastic, wet W). It might be caused by the probe deformation. However, no matter what, this kind of inconsistence above and below the solid objects should be explained. Otherwise, readers would not know exactly whether the inserted object affect the measurement of soil wetness below it or not.

Response: The main information about the influence of objects is in the reflectogram. The reflectograms show in all cases heterogeneous profiles. We attribute differences below the solid body to limit repeatability of these experiments and to boundary effects during medium and wet conditions. The TDR probe was carefully installed so that we could guaranty no probe deformation.

2. The heterogeneity considered in soil water dynamics mainly acts as different soil layers. The steady or transient flow in layered soil has been studied for few decades. The method proposed in this paper would be a useful tool to study this topic. If the author could conduct several experiments on the layered soil instead of solid objects, the scientific significance would be improved significantly.

Response: Layering of a soil is to our understanding no sign of heterogeneity but of

deterministic structure. The original intention of the study of Zehe et al. (compare same issue), were the investigation of inversion in layered soils. However, after installing we found that maintaining rod geometries is almost in every position impossible due to the high amount of gravel. We thus focused on the effect rod deformations on inverted profiles. If inversion is not feasible in case of deformed probes we think it is of academic interest to study inversion of using non deformed rods in layer cohesives, because you never achieve ideal geometry in these soils. In this sense the paper explores first order error sources. Furthermore, repeating experiments were already most difficult in a medium with one soil layer (seemed to be homogeneous). Though we admit this would be interesting we think it is much more difficult in case of several layers.

Zehe, E., Graeff, T., Morgner, M., Bauer, A., Bronstert, A. (2009): Plot and field scale soil moisture dynamics and subsurface wetness control on runoff generation in a headwater in the Ore Mountains. Hydrol. Earth Syst. Sci. Discuss., 6, 7503-7537.

3. The experiment procedures in section 4 needs to be described in more detail. For example, is the glass bead same in all five experiments? What is the size of T-pieces? What is the size of the THETA probes? Is there inter-influence between THETA and SUSU03? How can you ensure the soil moisture levels achieved? and so on.....;

Response: This will be better explained in revised version. Two T-pieces with a diameter of 16 cm and a length of 9 cm in the tube allowed for the installation of THETA probes (THETA, Delta-T-Devices). Technical details of the probes are: a shaft length of 11 cm, rod length of 6 cm and a diameter of 4 cm. One probe of type SUSU03 was installed in the centre of the tube with rods pointing from the upper edge of the tube to the bottom. Independent soil moisture measurements were obtained with two THETA probes placed at a depth of 30 and 55 cm, which work in the FDR domain with a measurement error of $\pm$0.01 m^3m^{-3} (Gaskin and Miller, 1996). The THETA probes reach 3 cm into the centre tube. The rods of the THETA probes have a distance of 5 cm to the the rods of the SUSU03 to avoid interaction on measured signalsand which were consistent with the observations of Ferré et al. (1998) and Petersen et al. (1995). This

was proven by investigation of the reflectograms. The water levels were not taken into account because of capillary effects in the pipe. We just investigate the reflectograms and compared them with the THETA probes.

Ferré, T.P.A., Knight, J.H., Rudolph, D.L., Kachanoski, R.G.: The sample areas of conventional and alternative time domain reflectometry probes, Water Resources Research 34, 2971-2979, 1998.

Peteresen, L.W., Thomsen, A., Moldrup, P., Jacobsen, O.H., Rolsten, D.E.: High resolution time domain reflectometry: sensitivity dependency on probe-design, Soil Science 159(3), 149-154, 1995.

4. In experiment 2, the transient conditions was checked. However, according to the Fig.4 and Fig.6, the cross-check between the measurement of SUSU03 and THETA is not correct due to the T-pieces. According to Fig.4, the THETA was in T-pieces, which actually will retain more soil water during drainage due to soil moisture diffusion. That is why in Fig.6, the THETA measurement is always wetter than SUSU03 measurement. On this point, the discussion related to this part is not correct also.

Response: We thank the reviewer for this important point. We admit that THETA and SUSU03 measure soil moisture not at the same place, which explains differences in observed values (and highlights the difficulty to achieve homogeneous setup of the pore space). Furthermore, we have to assure a certain distance to avoid interaction between the two probes. This will be clarified in the text of the revised manuscript.

5. In section 5.6, the description of Fig.9c is not completely correct. What the author argued is just for the moisture measurement at depth of 50cm not for 20cm. More details needs to be provided.

Response: Thanks for that comment, we will check this and clarify it if necessary. During the events we overestimate what is observed at both depths. Otherwise we underestimate.

6. There are too many subtitles, which make the article fragment. For example, in section 3.5, there is no need to use two subtitle, which are not so related to the 3.5 title, to demonstrate the error sources. Reader can understand that with only 3.5 title. In section 4 and section 5, the experiment description and the results discussions could be combined, which would make the paper more brief and clear.

Response: We thank for this suggestion and will merge sub sections.

7, some small mistakes: Page 271 line 7 "heterogonous" should be "heterogeneous"; page 287 line 15 (Fig. 9c) should be (Fig. 9b);

Response: Will be fixed.

Interactive comment on Hydrol. Earth Syst. Sci. Discuss., 7, 269, 2010.