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Hydrology and Earth System Sciences Discussions

Interactive comment on "Multi-method geophysical measurements for soil science investigations in the vadose zone" *by* B. Weihnacht and F. Börner

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Summary

The authors present an interesting experimental study that aims on simultaneous determination of soil water content, porosity, apparent density and cation exchange capacity along the vertical profile of a soil outcrop of 40 cm thickness at a site near Heidelberg. The approach is to relate geophysical proxies (dielectric permitivity, compressional wave velocity, specific electric ressistivity, electrical phase shift) determined from geophysical measurements (electrical resisstivity tomography, radar tomography

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and ultra sounding) to the target variables by means of parametric petrophysical relations. The petrophysical relations are calibrated by using soil samples that were extracted along the vertical profile and are analysed for the target variable in the lab. The presented results are convincing in the sense that a) the different geophysical proxies show are consistent along the soil profile and allow an identification of the 4 major soil horizons and b) the petrophysical relations are flexible enough to allow a reasonable to good fit of the soil water content, and the other soil characteristics along the soil profile. This underpins the potential value of combining different geophysical methods for characterising states and parameters the in the unsaturated zone in a non destructive manner. However, in the present form the paper suffers from several serious short comings. I therefore recommend major revisions that should address the following major and minor points.

Major points:

-In the beginning the authors state that investigations of soil content are complicated by the high resolution require in depth. This is a very vague statement! I am not sure, what this statement shall tell me? Do you mean that it is difficult to obtain representative soil moisture data? (I of course agree, but please be precise in what you want to tell). One major problem of getting representative soil moisture data is of course the small support/integration volume of lets say TDR observations that is much smaller than the REV of the soil water content. In this respect, the authors are totally right with their statement, that geophysical measurements are superior, because they solve the problem of incompatibility of measurement and process scale. However, the authors should remember that there are additional factors that hamper the assessment of representative soil moisture data. Non stationarity of the pore space (plowing, activities of soil biota), water flow in non capillary pores still hampers understanding and modelling (which can themselves be non stationary), hydrophobicity in some parts, threshold phenomena and so on. Soils are to a certain degree unique, means that a sandy loam in at a soil outcrop in Heidelberg might behave totally different from a sandy loam in a forested site

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in the Ticino. I therefore strongly doubt that the strategic goal of this paper is realistic. The authors state that they will develop general "petrophysical" relations with meaning full parameters (somehow related to soil characteristics) that allow estimation of hydrological state variables/ parameters from geophysical proxies without a site specific calibration. This won't work because of the reasons stated above. It strongly reminds me of the problem of pedo-transfer functions, which are a good first guess for average soil hydraulic properties, but often totally fail when going to a concrete field site.

-In this light a more thorough discussion of the promise and the limits of the methodology is urgently needed! The extend of the outcrop is 40 cm, do you regard this as sufficiently large when dealing with strongly heterogeneous soils? What would be the normal way of applying this methods, digging two trenches? How strong is the influence of lower boundaries (air in 40 cm) on the electric measurements?

-The authors claim that b & n in Eq. 7 are parameters specific to the pore space, but they use the same values along the profile, even in the gravel rich layer. This is not consistent with the intention of deriving soil specific petrophysical relations, as claimed in the intro. The parameters are either pure fitting parameters, which means you will always have to calibrate, or the parameters should be different at least for the gravel layer.

-It would be very instructive to see scatter plots of the target variable and the geophysical proxies, to evaluate the fit (e.g. dielectric permitivity against soil water content). What are the confidence limits of the parameters (it is a non linear regression!) Did you include the all the data from the soil samples into the fitting procedure? A split sampling strategy (leaving some samples out and predict their properties/water content) would convince the reader that the approach allows predictions at least inside the same profile.

Minor points Section 1

The statement that petrophysical parameters from geophysical measurement are be-

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coming more and more "popular" for environmental applications, is to my feeling not true. The studies listed after this statement are to my feeling not "normal applications", they are fundamental research studies. It would be very instructive to give some sort of synthesis of the listed studies: We are we now in this field, what are the challenges? How does is our study related to these challenges.

Section 2.2 and 2.3

-As far as I know determination of the gravimetric water content requires oven drying at 105 C until the weight is constant? Why using only 70 C?

-How do you know that the porosity measurements in the lab have a systematic error? Do you have independent data from the field?

-Please use different variable names for fitting parameters and other variables (e.g. a for spacing in the Wenner array and in Eq. 5 and Eq. 6.

-Did you use the measurements of the total density derived from the soil samples for estimating c by combining Eq. 8 and 9?

Section 2.5

-It would be very interesting to get some explanation for the drop in the epsilon profile below 40 cm! It may obviously not explained by differences in soil water content or in relative saturation (porosity and soil moisture are constant).

-Can you please explain the systematic underestimation of soil water content in the gravel layer?

Section 3.

- It would be very instructive to discuss the obtained results, the error sources etc. with respect to the literature the authors refer to in the intro. Especially the study of Wollschlaeger et al., who worked on the same site, should act as kind of "bench mark"; for discussing the approach and findings presented in this study.

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Interactive Comment

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