

General comments on “Reflection tomography of time-lapse GPR data for studying dynamic unsaturated flow phenomena”

Characterization of unsaturated soil water flow at different scales is essential to understand the underlying mechanisms. The potential capability of GPR has been demonstrated in a variety of studies. Identification of transient water flow using GPR is relatively easy, while proper quantification of the variability of water content in time and space is still challenging for GPR in the post-migrated domain. This study presents an efficient monitoring system to characterize sub-meter scale heterogeneous flow in a sand tank. Generally, this study is well written and presented. However, the capability of the proposed approach for quantitatively monitoring transient flow at sub-meter scale is still lack of persuasion, according to the results from the synthetic and laboratory studies. Nevertheless, this technique is promising to capture some very transient water flow peaks in space, in particular in structural soils, while it is difficult for common point measurements.

1. The authors demonstrate the coupling automated GPR data collection with reflection tomography in synthetic studies and laboratory studies. Given a perfect hydrological model for a homogenous soil, the considerable discrepancy (5~10%) between the true water content and the estimates from reflection tomography indicates the proposed approach is not ready for hydrological applications. Further analysis of the accuracy of the tomography approach is needed.

2. Provided such an irrigation setup for surface infiltration, heterogeneous water flow could be expected. I am wondering how these small-scale heterogeneities within a CMP gather influences on the accuracy of the reflection tomography algorithm. Please clarify this.

3. The error (5~10%) in the synthetic studies mainly comes from the artifacts, while the serious error (5~15%) in the laboratory studies might be from improper probe locations. Concerning the foreseeable heterogeneous water flow, the comparison on the reflection tomography estimates with the probes half-meter away might not make sense. Hence, more solid validation is required to consolidate the quantitative characterization of dynamic unsaturated flow phenomena. Finally, the relationships between the two error levels (5~10% vs. 5~15%) should be discussed.

4. The authors just demonstrate the discrepancies between reflection tomography and Probes for three-time slides (0, 95 and 173). Considering the fast evolution of the heterogeneous wetting, I am wondering how the discrepancies evolve.

Mineral comments:

(1) L40-41: I didn't find a multi-offset survey for infiltration experiment in Gerhards (2008). Besides, the journal name is missing in the reference.

(2) L124: 'mS/m' to 'mS m⁻¹'.

(3) L134: 'Reflection TOMography Of simulations' to 'Reflection Tomography of Simulations'

(4) Line 219: The format of paper title should be just capitalized the first word. Same issue for other references.