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Contribution ID: **328** Type: **Oral Presentation**

Magnetic resonance imaging of water content and flow processes in natural soil using pulse sequences with ultrashort detection

Friday, 4 June 2021 10:40 (15 minutes)

Background: Soil water processes take place partly on small scales and are prone to distortion by invasive methods. Therefore, non-invasive imaging techniques are mandatory for their analysis and subsequent improved understanding. Contrary to XCT, which is most sensitive to the structure of the solid matrix, MRI is well suited to monitor the liquid phase due to its sensitivity to the substance of interest: water. The contrast relies on the water content and the properties of the soil pore manifesting in changed NMR relaxation times. Therefore, MRI is highly convenient too for the imaging pore space properties in addition to the water content. Vice versa, reduced relaxation times of some milliseconds often counteract the imaging of water content when using conventional MRI pulse sequences. A way out are so-called pulse sequences with ultra-fast detection. The purpose of the present paper is to adapt and test such sequences for quantitative water imaging in natural soil.
Methods: All experiments were performed using a Bruker, vertical super wide bore scanner at 200 MHz resonance frequency, allowing the percolation and sampling of water during scans. After the determination of relaxation properties of several soil materials, we have compared conventional and ultra-fast detection MRI pulse sequences (MSSE, ZTE, and UTE) with respect to their convenience for quantitative imaging of water content. The quantification of water content was performed with soil core samples of sandy loam for water contents between ⍰ = 0.1 and 0.4 cm3/cm3. Next, the sensitivity for T2*blurring artefacts was tested at a composite sample with sand, sandy loam and silt loam soils. Finally, the optimal pulse sequence was applied for the mapping of flow processes in a natural soil core from Selhausen test site.*
Results: Sandy-loam soil has relaxation times of T1 = 80ms and two T2 fractions with 3 and 20 ms. Therefore, the conventional MSSE sequence hided larger fractions of water. In contrast, Zero-echo time imaging (ZTE) allowed the quantitative mapping of water content at a resolution of 0.5 mm in 3D in about 30 minutes/scan. T2 blurring artefacts were best eliminated for ZTE by increasing bandwith to 300 kHz. Combining all these results, we used ZTE for the monitoring of the transition from matrix flow to film flow in a wormhole occurring in a ponded infiltration experiment in a natural soil core above a critical infiltration rate of 3.6 cm/h.

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Conclusions: The issue of rapid relaxation in natural soil can be overcome by ultra-fast detection. Water content changes are reliably mappable and processes such as the transition from matrix to preferential flow is detectable.

Time Block Preference

Time Block A (09:00-12:00 CET)

References

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