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Combining neutron and X-ray imaging to study air and water behaviour in the soil macropores

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Infiltration of water and gas trapping in soil macropores were investigated on intact sample of coarse sandy loam soil (Cambisol series) taken from the B horizon by combined X-ray and neutron tomography imaging. The soil under study is known for the occurrence of the preferential flow, in which a majority of the water flux is conducted through small, highly conductive, fraction of the soil volume. Experiment performed in the NEUTRA beamline of Paul Scherrer Institut consisted of two infiltration episodes during which a layer of heavy and light water mixture was maintained on the sample surface created a ponding boundary condition. The initial state of the sample was recorded by one X-ray and two neutron scans prior to the first infiltration. Another 20 neutron tomograms were acquired during the following 25 hours of the experiment.
Fine co-registration of the reconstructed X-ray and neutron tomograms was performed. Then, bi-variate histograms helped to identify the thresholds that were subsequently used for segmentation of the macropores from the X-ray tomograms. The segmented regions served as a binary mask for calculating the water volume using the neutron tomograms. Volume of water and subsequently the average water content in the macropore system were calculated. Results then quantitatively show the extent of the water content reduction in the macropores during the second infiltration that was caused by enhanced air trapping in the wet soil.