Geophysical Research Abstracts
Vol. 19, EGU2017-11869, 2017
EGU General Assembly 2017

Comparing dynamic recording of infiltration by X-Ray tomography to the results of a dual porosity model for structured soils

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With climate change, preferential flow phenomenon in soil could be predominant in Mediterranean zone. Understanding this phenomenon becomes a fundamental issue for preserving the water resource in quantity (drinking water) and quality (pesticide content). Non-invasive imaging technics, as X-ray tomography, allow studying water infiltration in laboratory with time-lapse imaging to visualize preferential flow path in soil columns (Sammartino et al. 2012). The modeling of water flow with a dual porosity model (matrix and macropores) integrates these fast flow phenomena (Ilhem 2014). These models, however needs more explicit links with the soil structure. The comparison of experimental results of infiltration (dynamics images and mass data) and modeling could improve our comprehension of preferential flow phenomenon and allow a better integration of the functional macroporosity (i.e. which drains water infiltration during a rain event) in such mass transfer models (Sammartino et al. 2015).

Soil columns (Ø 12 cm – hauteur 13 cm, clay-loamy & medium sandy loam) have been sampled in the field to preserve their structure (field plowed or not). Several rains have been simulated in the laboratory and the last one was performed in an X-ray medical scanner (Siemens Somatom® 128 slices) at the CIRE platform (INRA, Centre – Val de Loire). Total and functional macro porosities were identified from time lapse tridimensional images. Water dynamics in the porosities was characterized from the identification and analysis of voxels filled by water. With an image resolution of 350μm only water in the largest macropores can be identified.

The modeling of these experiments was carried out via the VirtualSoil platform (UMR Emmah, Avignon; www6.inra.fr/vsoil) using a water flow model coupling Darcy-Richards and KDW equations (Di Pietro et al., 2003). The simulated water flux drained by macropores is similar to the experimental hydrograph obtained for rainfalls on soils close to the saturation.

The model reproduced well the flow dynamics: (1) breakthrough time (arrival time of the first drop at the bottom of the column) and (2) the total drained water quantity. A sensitivity analysis of this model is in progress in order to determine the influence of each KDW parameters (two kinematic parameters and one dispersion parameter) and to probe where the functional soil structure could be accounted for in the model structure or in the model parameters. First results show that the kinematic parameters modify the breakthrough time and the slope of the drainage curve.

Keywords: functional macroporosity, modeling, RX tomography, infiltration, Richards and KDW equations.

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