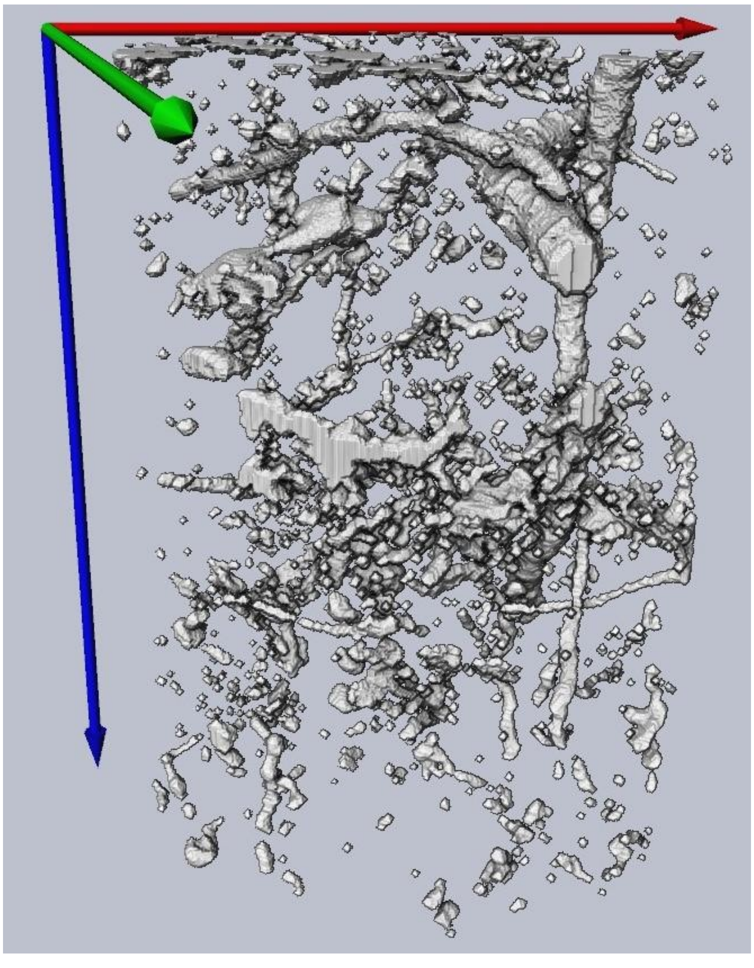
Abstract

Predicting the evolution of groundwater resource due to future climate change requires a better knowledge of water flows in soils which are highly complex porous medium. A lot of research has been conducted about soil water flow complexity over the last decades but predicting water flow in soils whatever soil texture, soil structure and rainfall intensities still remains a challenge. The objective of this work is to improve the modeling of water flow in structured soils by accounting to water flow from macropores to the soil matrix. We follow three successive steps : (i) to perform infiltration – drainage experiments on decimetric undisturbed soils columns under a medical tomograph to better observe flow phenomena within the soil macroporosity, (ii) to extract structural indicators from tomographic images, and study the macroporous soil structure, and (iii) to integrate structural indicators into a Darcy-Richards – KDW dual compartment flow model. Undisturbed soils studied are sampled from three different plots: (i) a clay soil worked in a field crop, (ii) a clay soil not worked in an orchard and (iii) a silt – sandy soil not worked and not cultivated. Three infiltration – drainage experiment are performed in a medical tomograph with fast image acquisition (~15 sec), 30 mm of water is supplied with a rainfall simulator and an intensity of 20 mm.h-1.
Infiltration duration was of 90 min followed by 30 min of drainage. In total, the tomographic follow-up takes 120 min. Each experiment is done at three initial moisture conditions: (1) field capacity, (2) matrix potential at – 4 m, and (3) matrix potential at – 8 m. The initial structure observed beforeeach infiltration shows that the soil macroporosity increases from 2 to 5% with the decrease of theinitial water content. This increase is higher for the two clay soils compared to the silty – sandy soil.
The hypothesis is that soil texture influences the evolution of the soil structure according to the matric water content. Thus, clay soils have the most variable soil structure over time, unlike silt–sandy soils which seem more structurally stable. Rapid movements of the soil structure during the infiltration and drainage phases was observed thanks to the time lapse tomographic monitoring. During water flow, soil macroporosity decreases between 7 to 30 % and increases again during drainage. The decrease of soil macroporosity during infiltration is more pronounced for the most saturated initial condition. The increase is less marked for the driest conditions. The hypothesis is that water flow along the macropores' walls destabilizes causes an 'over-swelling' of the walls, which reverses during drainage. The study of overall indicators show that temporal monitoring of macropores density and their volumes makes it possible to discriminate specific texture and tillage behaviors different for the three soils. Models performed with the addition of profiled data measured on tomographic image in water flow model show that these measurements allow to reconstruct experimental data. Although the gap between modelling and observation for the driest experiments seems to indicate that it is necessary to continue the study of macropores – matrix exchanges in unsaturated conditions. This requires further study of the movements of the structure during wetting – drying cycles but also during the fast water flux transit.



Key-words: soil, texture, tomographic imaging, modelling, Darcy-Richards – KDW, coupling, macroporosity, infiltration – drainage experiments.