Geophysical Research Abstracts
Vol. 18, EGU2016-12289, 2016
EGU General Assembly 2016


# Scaling preferential flow processes in agricultural soils affected by tillage and trafficking at the field scale

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There is an accumulation of experimental evidences that agricultural soils, at least the top horizons affected by tillage practices, are not homogeneous and present a structure that is strongly dependent on farming practices like tillage and trafficking. Soil tillage and trafficking can create compacted zones in the soil with hydraulic properties and porosity which are different from those of the non-compacted zones. This spatial variability can strongly influence transport processes and initiate preferential flow. Two or three dimensional models can be used to account for spatial variability created by agricultural practices, but such models need a detailed assessment of spatial heterogeneity which can be rather impractical to provide. This logically raises the question whether and how one dimensional model may be designed and used to account for the within-field spatial variability in soil structure created by agricultural practices. Preferential flow (dual-permeability) modelling performed with HYDRUS-1D will be confronted to classical modelling based on the Richards and convection-dispersion equations using HYDRUS-2D taking into account the various soil heterogeneities created by agricultural practices. Our goal is to derive one set of equivalent 1D soil hydraulic parameters from 2D simulations which accounts for soil heterogeneities created by agricultural operations. A field experiment was carried out in two phases: infiltration and redistribution on a plot by uniform sprinkle irrigation with water or bromide solution. Prior to the field experiment the soil structure of the tilled layer was determined along the face of a large trench perpendicular to the tillage direction (0.7 m depth and 3.1 m wide). Thirty TDR probes and tensiometers were installed in different soil structural zones ($\Delta$ compacted soil and $\Gamma$ macroporous soil) which ensured soil water monitoring throughout the experiment. A map of bromide was constructed from small core samples (4 cm diam., 2 cm height) taken from the face of a trench 12 h after the end of the tracer experiment. Successful modeling was performed using HYDRUS-2D after adjustments of soil hydraulic functions in which infiltration phase and final bromide map were reproduced. The 2D simulation was then extended to cover the water and bromide redistribution phase. Pressure heads, water content and bromide concentration data were averaged along the lateral dimension of the two-dimensional model domain and used as an input data to obtain hydraulic parameters for dual permeability model (1D) at various time stages. Manual fitting of the dual permeability soil properties was then performed using the HYDRUS-1D model and used to estimate a set of effective soil hydraulic parameters. First results indicate very good agreement with the two-dimensional data with high model efficiency values for water content (above 0.7) and bromide concentration (above 0.9) during the different time steps. By performing inverse manual modeling hydraulic properties of the fracture domain, which describes the preferential pathways, could be estimated. These results show that within-field soil heterogeneities could be accounted for in 1D models of water and solute transport used at the field scale using dual-permeability modelling.

Keywords: Preferential flow; Soil heterogeneity; Conventional tillage; Water flow; Bromide concentration; Dual-permeability model; HYDRUS 1D/2D