VADOSE ZONE MONITORING AND MODELLING OF WATER FLOW IN HILLSLOPE SOILS

HORST H. GERKE, ANNELIE EHRHARDT

Tracer application (KBr) underneath a cultivated topsoil along a 10 m trench perpendicular to the slope above plot LP7 of the CARBOZALF-D experimental field

Water movement in soils is of central importance for soil functions such as storage and filtering as well as nutrient and element cycling. Classic concepts of modelling soil water dynamics typically fail in case of fast infiltration processes and when predicting subsurface lateral flows along hillslopes. Within this collaborative project, the already existing long-term monitoring data from a lysimeter network and field experiments will be used to test alternative models for the onset of lateral water flow based on hydraulic non-equilibrium and hysteresis. The aim of the project is to develop an effective multi-dimensional model of water flow on hillslopes that combines non-linear onset of lateral flow and plot-scale preferential flow.

In well-drained, unsaturated soils, water moves predominantly vertically. Lateral flow is initiated at locations where the soil approaches water saturation and capillary forces lose relevance. The onset of lateral flow along impeding soil horizon boundaries and other heterogeneities in hillslopes cannot be described realistically even with spatially-distributed numerical 3D models. A process-based model concept for transient lateral flow in the unsaturated zone of hillslope soils is still missing. One major difficulty is that water dynamics in field soils exhibit non-equilibrium effects and hysteresis due to structural heterogeneities. Consequently, lateral flow is triggered already at local water potentials close to zero, i. e. far before complete water saturation occurs, as is commonly assumed. Another difficulty is the need for a 2D or 3D representation of the hillslope and the corresponding high demand of both data and computing power.

In the DFG project VAMOS, a conceptual framework will be developed to describe non-equilibrium dynamics and hysteresis for 1D vertical flow in a physically consistent way. The analysis is based on unique data sets provided by the VAMOS monitoring system and the TERENO-SoilCan lysimeter network, which continuously measures water content and matric potential in different field soils (3D) and lysimeters (1D) since 2013. Upscaling to the hillslope-scale will be accomplished by a dynamic lateral coupling of vertical 1D columns triggered by local water saturation (i. e. zero potential) in order to describe lateral flows at large scales with considerably reduced complexity. The overall project is structured in (1) unified concepts to model soil water hysteresis and hydraulic non-equilibrium, (2) the identification of field evidence for the onset of lateral flow at the hillslope scale, and (3) hillslope scale model development and evaluation. For model validation, joint experiments are carried out such as, for example, a bromide tracer experiment at the CARBOZALF-D experimental field and laboratory-scale percolation experiments. We expect a better prediction of the onset and dynamics of lateral subsurface flow in unsaturated soils and an improved understanding of the temporarily changing flow paths and travel times at the scale of hillslopes, which improves the currently limited prediction of solute transport in variably saturated soils and the vadose zone.

Project: Monitoring and modelling of non-equilibrium soil water dynamics and lateral subsurface flow in hillslope soils (VAMOS) **Term:** 2019–2021 **Sponsor:** DFG **Lead at ZALF:** H. Gerke (hgerke@zalf.de) **Partner:** TU Dresden, UFZ