Geophysical Research Abstracts
Vol. 17, EGU2015-2271, 2015
EGU General Assembly 2015

Heterogeneous reactive transport under unsaturated transient conditions characterized by 3D electrical resistivity tomography and advanced lysimeter methods

Markus Wehrer (1) and Lee Slater (2)

(1) Universität Jena, Institut für Geowissenschaften, Jena, Germany (markus.wehrer@uni-jena.de), (2) Department of Earth & Environmental Sciences, Rutgers University, Newark, US

Our ability to predict flow and transport processes in the unsaturated critical zone is considerably limited by two characteristics: heterogeneity of flow and transience of boundary conditions. The causes of heterogeneous flow and transport are fairly well understood, yet the characterization and quantification of such processes in natural profiles remains challenging. This is due to current methods of observation, such as staining and isotope tracers, being unable to observe multiple events on the same profile and offering limited spatial information. In our study we demonstrate an approach to characterize preferential flow and transport processes applying a combination of geoelectrical methods and advanced lysimeter techniques.

On an agricultural soil profile, which was transferred undisturbed into a lysimeter container, we systematically applied a variety of input flow boundary conditions, resembling natural precipitation events. We measured breakthroughs of a conservative tracer and of nitrate, originating from the application of a slow release fertilizer and serving as a reactive tracer. Flow and transport in the soil column were observed using electrical resistivity tomography (ERT), tensiometers, water content probes and a multicompartment suction plate (MSP). These techniques allowed a direct validation of water content dynamics and tracer breakthrough under transient boundary conditions characterized noninvasively by ERT.

We were able to image the advancing infiltration front and the advancing front of tracer and nitrate using time lapse ERT. Water content changes associated with the advancing infiltration front dominated over pore fluid conductivity changes during short term precipitation events. Conversely, long-term displacement of the solute fronts was monitored during periods of constant water content in between infiltration events. We observed preferential flow phenomena through ERT and through the MSP, which agreed in general terms. The preferential flow fraction was observed to be independent of precipitation rate. This suggests the presence of a fingering process driven by textural heterogeneities. As a consequence, preferential transport of the conservative and the reactive tracer also occurred.
We found that 3D ERT can serve to quantitatively characterize shape measures of both tracer breakthroughs and water content dynamics. In particular, shape measures influenced by the advective propagation of the tracer peak, like mean velocity and normalized first central moment, are highly correlated between ERT data and validation data (consisting of tracer measurements in seepage water samples). Using shape measures proved to be advantageous over interpretation of ERT data with spatially uncertain petrophysical functions for the characterization of heterogeneous flow and transport. Consequently, for future applications of ERT in soil hydrological modeling, the use of temporal moments is recommended.