Geophysical Research Abstracts
Vol. 13, EGU2011-2522, 2011
EGU General Assembly 2011

Estimating subsurface hydraulic properties from streaming potential signals obtained under variably saturated flow conditions

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Streaming potential (SP) is the electric potential generated by fluid flow in a porous medium. SP has been shown to be related to pore water velocity, bulk electrical conductivity, excess of charge in pore water and soil porosity. This implies that SP can be used to study subsurface flow and transport processes. Most attempts at inferring subsurface hydraulic properties from SP signals are limited to the saturated zone (ground water studies). There are relatively few studies which attempt to infer subsurface hydraulic properties from SP signals under variably saturated conditions. In this study, we first aim at investigating the feasibility of inferring three key Mualem-van Genuchten hydraulic parameters (α, n Ks) from SP measurements obtained during a falling head infiltration experiment followed by primary drainage using a synthetic case study. Synthetic SP measurements were directly used for estimating subsurface hydraulic properties by coupling a forward solution of the Poisson equation governing the distribution of streaming potential to a hydrological model describing the falling head infiltration and drainage experiment. Using a global optimizer, the hydraulic parameters in the hydrological model were perturbed to simulate pore water velocities, excess of charge in pore water and soil electrical conductivity profiles. These were then used in forward modeling to simulate streaming potentials which are compared to the corresponding measurements till a close fit was found. The synthetic case study showed that SP data obtained under variably saturated flow conditions can provide good information on the hydraulic parameters. In a next step, an actual experiment was performed that will also be discussed. It was concluded that the use of a coupled inversion approach allows inferring subsurface hydraulic properties from SP data.