Geophysical Research Abstracts
Vol. 15, EGU2013-2975, 2013
EGU General Assembly 2013

Front instability in stratified media

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Preferential flow in unsaturated soil may due to local heterogeneities like worm burrows but also to front instability leading to unstable finger flow (fingered pattern) in sandy textured soils. This last spontaneous preferential flow cannot be described by the standard Richards equation. Cueto-Felgueroso and Juanes proposed recently a phase field model in order to take into account a macroscopic surface tension effect at the front [1]. Their model simulates successfully the interface instability of an advancing front. We aim at simulating and understanding front instability passing a textural soil discontinuity for which the finger flow is particularly visible.
We consider sand layers with different characteristics such as granulometry. Moreover, the wettability is taken into account by adding a hydrophobic term in the free energy of the phase field model. The hydrophobicity part is not only relevant for repellent soil but also to model the ultra-thin films [2]. Therefore, in our framework, this may have an influence at the front because the water saturation is nearly zero. Such a wettability influence on infiltration in porous media has recently been measured in [3].
The governing equation is analogous to the lubrication equation for which we pointed out the specific numerical difficulties [4]. A numerical code to perform time integration and bifurcation analysis was developed in [4] allowing to determine the onset of instability and its resulting dynamics in the parameter space [5].
We compute the parameter range for which the front stops when reaching the layers interface. As in [4], there is two main mechanisms that allow water to cross over the discontinuity. A first mechanism, called «depinning», leads to an intermittent flow and the second one, to a front instability and then to a finger flow. There is a parameter domain where both instabilities are present leading to a complex spatio-temporal dynamics. Finally, it is noteworthy that the wettability property has a crucial impact on the fingering emergence.

References
[1] Cueto-Felgueroso and Juanes, Water Res. Res., 45, W10409 (2009).
[2] De Gennes, Rev. Mod. Phys. 57, 827–863 (1985).
[3] Goebel, Woche and Bachmann, vol. 442-443(6), (2012).
[4] Beltrame and Thiele, SIADS, 9, No. 2, pp. 484–518 (2010).
[5] Beltrame and Knobloch et al. Phys. Rev. E, 83, 016305 (2011).