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Hydrology and Earth System Sciences Discussions

Interactive comment on "Big and small: menisci in soil pores affect water pressures, dynamics of groundwater levels, and catchment-scale average matric potentials" *by* G. H. de Rooij

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General comments: The topic is interesting and timely; however, this is one of the most confused manuscripts I have seen in a while. The author (for whom I have great respect) mixes in this analysis pore scale with Darcy and catchment scales. For example, even in a naive approach one cannot attach geometrical attributes to mean curvature at scales greater than a few pores. Relying on capillaries for the analyses is really a step back and not a step forward masking the very complexity the author is attempting to unravel.

I found many of the definitions incomplete and lacking in rigor (some even involve what

would best described as hand waving). For example, the fundamental definition of the matric potential is incomplete and waives many important phenomena essential to understanding (from films to hydraulic continuity). The arguments related to changes in gravitational potential in differential form (eq. 3) are immature (in response to change in water table level or addition of water, one is not expecting a uniform planar change at the pore scale. One needs to decide, if pore scale is maintained then pore would respond differently and a plane change in water content would only be possible via simple vertical (hydrostatic) translation of the characteristic curve. The comments/discussion of motion of interfaces and small interfacial deformation under flow is not qualified nor substantiated.

Invoking pore scale arguments for describing motion of partially wet slug of water is not the most rigorous piece of work I have seen.. I am confident the author knows better (BTW this is where the author should have mentioned conditions for onset of instability and hence failure of some of the arguments but somehow decided to overlook this aspect).

Other than averaging over the mass or volume of soil water to obtain the correct formal definition of averaged matric potential - the contribution offers little new insights. The arguments are incomplete and add little to understanding of hydrological behavior of catchments. Some of the postulated process descriptions and related arguments are simply wrong and thus set the stage for unnecessary confusion.

Specific comments:

P 6492 l 14 – “The pressure-regulating effect of the interface curvature” – the curvature is a result of force balance and not a regulatory feature

P 6492 l 24 – “Unsaturated porous media can generally be described by the configurations” Better state that the energy state of liquid held in unsaturated porous media. . ..

P 6495 l 12 – “Matric forces matric potential negative” - This is the core of the paper -

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need more than a statement in passing, what do you mean by "negative"

P 6497 l 8 – “liquid occupied horizontal area” - in unsaturated media and in differential form this is not independent of the second term (see viscous or other forms of fingering). Need to decide about the scale – can’t keep pore scale and ignore pore displacement with withdrawal or addition of dV

P 6497 l 15 – as above - This is rooted in a confusion of scale and process - at the scale that curvature matters, this is not correct (see numerous works of Yortsos and Maloy’s groups)

P 6498 l 10 – “only determined by the volume of liquid experiencing these changes in pressure potential, not by the possibly very much smaller volume of liquid that brings these changes about.” - This again is incorrect - the phenomenon of drainage (even at very slow rates) may involve avalanches where a small removal of liquid volume results on a cascade or emptying of many pores... (Aker et al. EPL 2000)

P 6498 l 28 – can you "invent" a case with porous media where such hypothetical argument holds?

P 6500 l 13 – “the atmosphere modifies the pressure in the liquid phase” - for all practical purposes (especially for the scale of interest in this study) atmospheric pressure can be considered constant. In fact, it is in the basis of the definition of matric potential (reference state)

P 6501 l 18 – how exactly a pendular ring would "feel" a hydrostatic force? Other than gravitational force by own weight (mass in other gravitational fields) hydraulic continuity is needed to discuss hydrostatic equilibrium

P 6507 l 25 – “The pressure jump across the interface is quite large, and the water behind the drying front will be at a considerably lower pressure than the water at the wetting front” This sounds a bit like story telling - all of the changes will be subjected to conservation of mass and force balance!!!

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Interactive Comment

P 6507 l 28 – “with r the pore radius” - which pore exactly? we talking about a front with many pores

P 6510 l 7 – “In this case, the difference between the matric potential terms in Eq. (6) is zero.” - can you envision subjecting a body of water in unsaturated porous media to a gravitational field and keeping the matric potential (or curvature) constant ...

P 6517 Appendix A – If you are to repeat the exercise allowing for mass exchange between the capillaries (as natural soils and fringes do), the entire analyses and discussion would be different wouldn’t they?

In other words, the curvature in ALL capillaries subjected to the same gravitational head should be exactly the same. The geometry (pore throat) would then define which capillaries are invaded and which are not. The notion of an "average" curvature for a system in confined equilibrium (non-interacting capillaries) is a result of fictitious construct and has nothing to do with reality neither at the pore nor at the catchment scales...

Interactive comment on Hydrol. Earth Syst. Sci. Discuss., 7, 6491, 2010.