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Hydrology and Earth System Sciences Discussions

Interactive comment on "Assessment of water penetration problem in unsaturated soils" *by* A. Barari et al.

Anonymous Referee #3

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This is a potentially interesting and novel paper on analytical solution methods for Richards equation (RE), but it has several major flaws that would need to be addressed before I would recommend the work for publication.

1. The title needs to be more specific to the topic of the paper.

2. The first line of the Introduction mentions multi-phase flow, but this is not the subject of this paper.

3. The Introduction provides a good overview of RE and solution approaches for this nonlinear equation, with a decent survey of the literature. It is incomplete, however, to mention only "non-iterative solution" methods (line 14 of page 3813), as iterative

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methods (e.g., Picard and Newton) are by far the most common approaches used to linearize RE when solving this equation numerically. There are many references on this, amongst which:

- Paniconi, C., Aldama, A. A., and Wood, E. F., "Numerical evaluation of iterative and noniterative methods for the solution of the nonlinear Richards equation," Water Resour. Res., 27(6), 1147-1163, 1991

- Huang, K., Mohanty, B. P., and van Genuchten, M. Th., "A new convergence criterion for the modified Picard iteration method to solve the variably saturated flow equation", J. Hydrol., 178, 69-91, 1996

- Zhang, X. and Ewen, J., "Efficient method for simulating gravity-dominated water flow in unsaturated soils," Water Resour. Res., 36(9), 2777-2780, 2000

- Farthing, M. W., Kees, C. E., Coffey, T. S., Kelley, C. T., and Miller C. T., "Efficient steady-state solution techniques for variably saturated groundwater flow," Adv. Water Resour., 26(8), 833-849, 2003

4. In the Introduction, but also elsewhere, the authors need to make a major effort to place the HPM and VIM methods that they present in a proper context. What do these methods offer that existing analytical solution methods cannot achieve? Are they more general? Are they more accurate than other non-exact methods?

5. The references provided for both the HPM and VIM methods (l. 2-5 p. 3814 and l. 7-10 p. 3818) consist entirely of a few papers by He (presumably the originator of these methods) followed by a number of papers on which the authors of this submitted paper appear. It would be reassuring to provide additional references that show that other researchers have worked on and applied the HPM and VIM methods.

6. The paper needs to discuss possible restrictions in the applicability of HPM and VIM to RE (e.g., 1D only?; homogeneous soils only?; isotropic soils only?; specific types of boundary conditions?). The authors also need to be clear about what combination of

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conditions/restrictions they are using in this paper. Finally, if the HPM and VIM methods can be applied to more general conditions than those presented in this paper, some discussion as to how complicated it would be to do so should be provided. (See also point 10 below.)

7. Remove the "equals" sign after C(h) in equation (5).

8. L. 18 p. 3816: In numerical RE models it is no more "difficult" to implement van Genuchten soil hydraulic functions than Brooks-Corey. This sentence should perhaps be made specific to "analytical solution schemes".

9. Eqn (12): Please use the same notation for partial differential equations as used in the previous equations.

10. The authors apply HPM and VIM to only 2 very specific cases of RE with Brooks-Corey functions (n=1 and n=2, as described on p. 3818). Why were these values selected, and are the methods applicable more generally? Also, what sort of soils correspond to these n-values?

11. It seems that by using n=1 and n=2 the Richards equation reduces to Burgers' equation. If this is so, how is this paper distinct from previous work by these authors that have applied HPM and VIM to Burgers' equation? (e.g., Ghotbi et al., 2008a cited in the References).

12. The authors should make an effort to explain the HPM and VIM methods (on pp. 3819-3820) in less abstract/mathematical terms that could be more easily appreciated by the readership of a journal such as HESS. The short description of the VIM method (section 4) is particularly impenetrable.

13. L. 8-9 p. 3820: Please elucidate these "drawbacks" and "advantages" between HPM and traditional perturbation methods.

14. In sections 5 and 6 it would help if the authors developed the HPM and VIM implementations using the notation and parameters of the Richards equation as presented

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in eqns (7), (10), and (11) (as in fact they claimed they would do on l. 11-13 of p. 3818). Where for instance is the parameter D_o (from eqn 10) in the solutions presented in eqns (34), (44), (51), and (58)?

15. The authors should state clearly how many terms they are using in the HPM and VIM series solutions, and they should discuss why they chose to truncate the series where they do, and what are the accuracy implications of doing so? (and also how difficult is it to derive additional terms if needed? For instance on l. 6 p. 3822 it is mentioned that the Maple package needed to be used to derive additional terms).

16. Please describe the "exact solution" that is mentioned at the bottom of p. 3824 and that is used in Figures 1 and 2. Is it eqn (13)?

17. Please provide some physical interpretation of the test cases that are used (and shown in Figures 1 and 2), including boundary conditions, initial conditions, and so on. Do these cases represent infiltration problems, for instance? And for what types of soil?

18. In the results for the n=1 and n=2 tests, the HPM and VIM methods apparently produce identical results. What are the differences, including pros and cons, between these two methods?

19. The paper is generally well-written but there are minor grammatical errors throughout the paper.

Interactive comment on Hydrol. Earth Syst. Sci. Discuss., 6, 3811, 2009.