InterPore2021 Online
13th Annual Meeting
31 May - 4 June 2021
Don't miss a moment!
Plan to view presentations before the conference

Contribution ID: **766** Type: **Oral Presentation**

Accurate determination of the time-validity of Philip's two-term infiltration equation

Monday, 31 May 2021 20:50 (15 minutes)

Many different equations have been proposed to describe quantitatively the infiltration process. These equations range from simple empirical equations to more advanced deterministic model formulations of the infiltration process and semi-analytical solutions of Richards' equation. The unknown coefficients in these infiltration functions signify hydraulic properties and must be estimated from measured cumulative infiltration data, $\tilde{I}(\tilde{t})$, using curve fitting techniques. From all available infiltration functions, the two-term equation, $I(t) = S\sqrt{t} + cK_{\text{s}}t$ of Philip (1957) has found most widespread application and use. This popularity has not only been cultivated by detailed physical and mathematical analysis, the two-term infiltration equation is also easy to implement and admits a closed-form solution for the soil sorptivity, S (L/T$^{1/2}$), and multiple, c (-), of the saturated hydraulic conductivity, K_{s} (L/T). Yet, Philip's two-term infiltration function has a limited time validity, t_{valid} (T), and consequently, the use of measured cumulative infiltration data, $\tilde{I}(\tilde{t})$, beyond $t = t_{\text{valid}}$ will corrupt the estimates of S and K_{s}. Philip (1957) provides theoretical guidelines on the time validity, yet, these estimates need to corroborated experimentally. In this paper, we introduce a new method to determine simultaneously the values of the coefficient c, hydraulic parameters, S and K_{s}, and time validity, t_{valid}, of Philip's two-term infiltration equation. Our method is comprised of two main steps. First, we determine independently the soil sorptivity, S, and saturated hydraulic conductivity, K_{s} by fitting the implicit infiltration equation of Haverkamp et al. (1994) to measured cumulative infiltration data using Bayesian inference with DREAM Package of Vrugt (2016). This step is made possible through a novel, exact and robust numerical solution of Haverkamp's infiltration equation, and returns as byproduct the marginal distribution of the parameter β. In the second step, the maximum likelihood values of S and K_{s} are used in Philip's two-term infiltration equation, and used to determine the optimal values of c and t_{valid} via model selection using the Bayesian information criterion. To benchmark, test and evaluate our approach we use cumulative infiltration data simulated by HYDRUS-1D for twelve different USDA soil types with contrasting textures. This allows us to determine whether our procedure is unbiased as the inferred S and K_{s} of the synthetic data are known before hand. Results demonstrate that the estimated values of S and K_{s} are in excellent agreement with their "true" values used to create the infiltration data. Furthermore, our estimates of c, β and t_{valid} depend strongly on texture and fall within the ranges reported in the literature. Our findings are corroborated by analysis of real-world data. Our study addresses four areas of active research by Prof. Vereecken, namely (1) measurement and modeling of water infiltration into variably-saturated soils, (2) development of numerical methods for subsurface flow and transport, (3) soil moisture measurement and characterization and (4) inverse methods and uncertainty quantification. As I have known Harry for about 15 years and visited him on several occasions, I'd be remiss if I did not share a few personal anecdotes about him (time permitting).

Time Block Preference

Time Block C (18:00-21:00 CET)

References

1. M. Rahmati, J. Vanderborght, J. Šimůnek, J.A. Vrugt, D. Moret-Fernández, B. Latorre, L. Lassabatere and H. Vereecken, Soil hydraulic properties estimation from one-dimensional infiltration experiments using characteristic time concept, Vadose Zone Journal, 19:e20068, 2020.
2. J.R. Philip, The theory of infiltration: 1. the infiltration equation and its solution, Soil Science, 83 (5), 345–358, 1957.
3. H. Vereecken, J.A. Huisman, H. Bogena, J. Vanderborght, J.A. Vrugt and J.W. Hopmans, On the value of soil moisture measurements in vadose zone hydrology: A review, Water Resources Research, 44 (4), W00D06, 2008.
4. J.A. Vrugt, Markov chain Monte Carlo simulation using the dream software package: Theory, concepts, and matlab implementation, Environmental Modeling & Software, 75, 273–316, 2016.
5. R. Haverkamp, P.J. Ross, K.R.J. Smettem and J.Y. Parlange, Three-dimensional analysis of infiltration from the disc infiltrometer: 2. physically based infiltration equation, Water Resources Research, 30 (11), 2931–2935, 1994.

Acceptance of Terms and Conditions

Click here to agree

Newsletter

I do not want to receive the InterPore newsletter

Student Poster Award

Primary author: Prof. VRUGT, Jasper (University of California Irvine)

Co-author: Mrs JAISWAL, Parakh (University of California Irvine)

Presenter: Prof. VRUGT, Jasper (University of California Irvine)

Session Classification: MS25

Track Classification: (MS25) Subsurface Water Flow and Contaminant Transport Processes –Special Session in Honor of Harry Vereecken