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Analytical determination of transition time between transient and steady state water infiltration

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The hydraulic characterization of soil hydraulic properties is a prerequisite to the modelling of flow in the vadose zone. Since many years, numerous methods were developed to determine soil hydraulic properties. Many of these methods rely on water infiltration experiments and their analysis using analytical or numerical models. At the beginning, most models were developed for water infiltration at steady state. These models had the advantage to be easy to develop from a theoretical point of view. Yet, many drawbacks remain including the need to wait for a long time, leading to time-consuming experiments, the risk to infiltrate water in large volumes of soil, leading to a response affected by soil variability, and the uncertainty regarding the attainment of steady state (i.e. constant infiltration rate). More recently, infiltration models and mathematical developments addressed the case of consecutive transient and steady states. Yet, one main problem remain. In the field, the operator is never sure about the state of water infiltration data. This paper present analytical formulations for the estimation of a transition time. We consider the model developed by Haverkamp et al. (1994) linking 1D infiltration flux to cumulative infiltration and related approximated expansions. An analytical method based on scaling is proposed to define transition time values in terms of both scaled cumulative infiltration and times. Dimensional times are then calculated for a large variety of soils and initial conditions. These time database can be considered as a relevant tool for the guidance for operators who conduct water infiltration experiments and wants to know when to stop and also for modelers who want to know how to select the data to fit transient or steady state models.

Haverkamp, R., Ross, P. J., Smetten, K. R. J., Parlange, J. Y. (1994), Three-dimensional analysis of infiltration from the disc infiltrometer: 2 Physically based infiltration equation. Water Resour. Res., 30: 2931– 2935, doi: 10.1029/94WR01788.