Wetting Moisture Characteristics Curves Derived from Constant-Rate Infiltration into Thin Soil Samples

Perroux et al. (1982) have presented "a rapid and precise method for obtaining a wetting curve by supplying a small constant flux of water to the top of a thin section of soil." It may seem paradoxical that a dynamic method might be advantageous in determining a water retention curve which is a static property. This, as well as the meaning of a small flux and a thin section, are the purpose of this comment. As a result simpler procedures and some improvement in the interpretation of the data will be proposed.

If we assume that time $t_w$ is the earliest time when the profile in the short section is near uniform, so that measurement of the pressure $h$, at one end is representative of the whole sample, then we must have

$$(\theta_0 - \theta_i) L \approx v_i \omega_i$$  \hspace{1cm} [1]$$

where $L$ is the thickness of the section and $v_i$ the imposed flux at $z = 0$, where $\theta = \theta_i$ and $\theta_i$ is the initial water content. We should expect that by that time $K(\theta) \approx v_i$, where $K$ is the conductivity. Thus the rate of application $v_i$ effectively imposes the first value of $\theta_0$ where reliable results can be obtained for $h$. For instance $v_i \approx K_0 \approx 4.84 \times 10^{-4}$ m/sec$^{-1}$ corresponds, roughly, to $\theta_0 = 0.13$ according to Fig. 2 and 5 of Perroux et al. (1982) with $L = 1.29$ cm and $\theta_i = 0.05$. Eq.[1] gives $t_w \approx 6$ h. Repeating the calculation with a flux 10 times larger gives $\theta_0 \approx 0.16$ and $t_w \approx 0.8$ h. Both times are good estimates of the times necessary for the profiles to be uniform across the section, as shown in Fig. 6 by Perroux et al. (1982) following a more complex calculation.

Thus the chosen flux, $v_i$, implicitly controls the first value of $\theta = \theta_i$ through the relation $v_i \approx K(\theta_i)$, where the first value of $h(\theta)$ can be obtained. Hence a "small" flux is necessary if $(\theta_0 - \theta_i)$ is not to be too large. However the condition of constant flux is not necessary to obtain the point $h(\theta_i)$. One could, more easily, inject a known amount of water, i.e. $(\theta_0 - \theta_i)L$, at any flux $Q$, not necessarily constant, greater than $v_i$, and then wait for redistribution of water in the section. Under those conditions the waiting time to obtain a practically constant $h$ at the bottom of the sample will be, if anything shorter than $t_w$ thus saving time. In addition by injecting a fixed amount of water the value of $\theta_i$ can be controlled a priori, while in the Perroux et al. (1982) technique the value of $\theta_i$ is a priori unknown.

Furthermore subsequent measurements, i.e. $h(\theta)$, e.g. with $\theta_1 - \theta_i = 2(\theta_0 - \theta_i)$, and so on, can be easily obtained by reinjecting a known quantity of water and, more importantly, the waiting time, $t_1$, will become increasingly shorter than $t_w$ as the section is wetter, since $K(\theta)$ increases rapidly with $\theta$. On the other hand with a constant flux the waiting time $t_1 = t_w$ by definition.

The rapid injection of known quantities of water and waiting for equilibrium to be established emphasizes the quasi-static, and not dynamic, nature of the measurement, while the increasingly shorter waiting time to establish equilibrium, as $\theta$ increases, should significantly reduce experimental time by effectively increasing the rate of application of water.

Finally, the "thin" section is necessary to have a near uniform water distribution in the soil. At, or near, equilibrium the small $\theta$ variation in the section is that of $h(\theta)$. Hence if $\theta_i$ is the known average water content in the section, and if $h_1$ is the measured water pressure at the bottom of the section then a better estimate of $h(\theta)$ is

$$h(\theta) = h_1 - \frac{1}{2} L$$  \hspace{1cm} [2]$$

instead of $h(\theta) = h_1$ taken by Perroux et al. (1982). Indeed the correction must be small for the method to apply and as long as it is small the section is "thin." The correction proposed then represents an easy way to improve the interpretation of the data with no additional work, and as long as the correction is small the method is reliable.

Received 8 Nov. 1982

The School of Australian Environment Studies
Griffith University
Brisbane, Qld, 4111 Australia

J. Y. PARLANGE

References


A Critique of Some Recent Attempts to Characterize Spatial Variability


I. Russo and Bresler (1981)

Russo and Bresler derive distributional properties of several hydraulic parameters, modeling each as a stationary, isotropic, random function. After fitting autocorrelations of a specific type to the data and determining the integral scale of each parameter, the authors conclude that "the typical shape of the autocorrelation function . . . , together with the existence of an integral scale, imply that each of the six parameters can be viewed as a stationary stochastic process." Since the autocorrelations were fitted on the basis of a stationary model and were chosen from a class of autocorrelation functions having specific shapes, this reasoning is circular and the above conclusion is unwarranted. Assessing stationarity is very difficult and requires more data than are reported in the paper. This issue is discussed too briefly by Yevjevich (1972). Incidentally, an integral scale will always exist for the above class of autocorrelations, but this has nothing to do with proving stationarity.

Russo and Bresler use $\chi^2$ goodness-of-fit tests and normal (or lognormal) probability plots to determine the distributions of the parameters, but again the conclusions are not well founded. The $\chi^2$ tests in Table 2 are based on few data and degrees of freedom, and so are not very discriminating. For example, where normality is accepted, many nonnormal distributions would also be acceptable [see Breiman (1973), p. 202–204]. A more serious criticism of both the $\chi^2$ test and of probability plots is that both methods require independent, identically distributed observations, whereas the whole point of the paper is that the observations are not independent (p. 682). The conclusion that the distributions are "independent of spatial position" has also not been demonstrated since the data from all locations were lumped into one probability plot.

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