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Response to "Comments on 'Integral Method for Estimating Soil Hydraulic Properties' by Hu (2015)"

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We thank Hu (2015) who provided an interesting comment on Shao and Horton (1998). He really made a great effort in commenting on our paper by reading many related publications and deriving quite a few equations. We appreciate his statement that our integral method has been widely used, because the method has the advantages of simplicity and uniqueness for estimating van Genuchten (1980) hydraulic property parameters.

Earlier, Xu (1999) commented on our integral method. However, the Xu (1999) derivation was not perfect, as stated by Hu (2015). The comments by Hu (2015) are close to being perfect, but he makes a small change in the expression of the original Eq. [13] and [14]. This change results in small, but very important, changes in the final expressions of the van Genuchten parameters α and n.

The original expressions considered by Shao and Horton (1998) are as follows:

$$\theta(\lambda)=\begin{cases}\theta_s-(\theta_s-\theta_i)\left(\dfrac{\lambda}{d}\right)^n & 0<\lambda<d\\ \theta_i & d\le\lambda<\infty\end{cases}$$

Hu (2015) changed the open interval to be a closed interval for the first equation of the piecewise function. He changed the lower limit from a closed one to an open one for the second equation of the function. The $h(\lambda)$ expressions were given similar changes, too. The changes in the limits produce changes in the final expressions of α and n**.** Unfortunately, the expressions of α and n provided by Hu (2015) are practically useless. Both expressions contain the term $K(h_i)$. Because the numerical value of $K(h_i)$ is unknown, the numerical values for the Hu (2015) α and n are also unknown. Thankfully, the original expressions of α and n presented by Shao and Horton (1998) are valid, and the numerical values of α and n can be determined from horizontal infiltration measurements.

The relationship between dh/dλ and Boltzmann variable λ should express as:

$$\frac{dh}{d\lambda}=\begin{cases}-b_1 & 0<\lambda<d\\ 0 & d\le\lambda<\infty\end{cases}$$

There is a printing error in Hu (2015) in the first expression of the interval. It is d instead of λ. Therefore, according to his derivation:

$$\int_0^\infty \frac{\mathrm{d}}{\mathrm{d}\lambda}\left[K(h)\frac{\mathrm{d}h}{\mathrm{d}\lambda}\right]\mathrm{d}\lambda=\int_0^d \frac{\mathrm{d}}{\mathrm{d}\lambda}\left[K(h)\frac{\mathrm{d}h}{\mathrm{d}\lambda}\right]\mathrm{d}\lambda+\int_d^\infty \frac{\mathrm{d}}{\mathrm{d}\lambda}\left[K(h)\frac{\mathrm{d}h}{\mathrm{d}\lambda}\right]\mathrm{d}\lambda$$

$$=\left[K(h)\frac{\mathrm{d}h}{\mathrm{d}\lambda}\right]\Big|_0^d+\left[K(h)\frac{\mathrm{d}h}{\mathrm{d}\lambda}\right]\Big|_d^\infty$$

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The second term of the above right hand side is 0, because $dh/d\lambda = 0$ in the interval of (d, ∞). The first term is $b_1 K_s$ rather than $(-b_1[K(h_i) - K_s])$, because the value of $dh/d\lambda$ at d is zero instead of $(-b_1)$, if the closed lower limit is used rather than the open limit of d. By the way, his second term of the integral should be "+" instead of "-". We believe it is a typo.

We had hoped that our response, Shao and Horton (1999) to Xu (1999), made clear that the original expressions of α and n were correct in terms of a first order approximation of the $h(\lambda)$ relationship. Hopefully, our present response helps to remove any remaining confusion. The original expressions of α and n presented in Shao and Horton (1998) are correct and useful. Thus, we encourage the soil physics community to employ this simple integral method for estimating soil hydraulic property parameters.

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