Evaluation of Different Parameterizations for the van Genuchten Soil Water Retention Function

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The van Genuchten (VG) equation is often used to describe soil water retention (WR) data relating the water content (θ) with suction (s). The model is commonly implemented with four independent parameters, i.e., α, n, θ_r, and θ_s. Many applications use only three parameters (α, n, θ_r), which has some advantages such as minimizing possible correlation among the parameters and simplifying inverse methods for estimating the parameters. The two VG parametrizations are usually applied to a large number of experimental WR data points that cover a broad range of suctions. Experimentally this is very time consuming and expensive. The objective of this study was to compare the performance of the VG parameterization using only three parameters and only three data points with more detailed descriptions in terms of a larger number of retention parameters and experimental data points. We selected for this purpose 1565 undisturbed soil samples from Brazil and Europe, with each data set containing at least five WR measurements covering a wide range of suctions (0-15,000 cm). Four different cases were studied. For Cases 1 and 2 we optimized three parameters (α, n, θ_r) by assuming the saturated water content (θ_s) to be known, whereas for Cases 3 and 4 we considered all four parameters (α, n, θ_r, θ_s). For Cases 1 and 4 we used only three unsaturated data points, plus the measured θ_s value, while for Cases 2 and 3 we used all available WR data. The three unsaturated WR data points of Cases 1 and 4 were the data at suctions closest to 60, 330 and 15,000 cm. Results showed that the corresponding WR estimates calculated for Cases 1 to 4 had no statistical differences between them for suctions above 30 cm (using the paired t-test), at a high probability level (p>~0.50). In general, the four configurations were able to describe water contents accurately within this suction range, with global RMSE (root mean squared) values varying from 0.011 cm^3cm^{-3} (Case 3) to 0.014 cm^3cm^{-3} (Case 1). On the other hand, in the wet range for suctions less than 30 cm, the fitted θ-values did not compare well, with Case 3 providing the most accurate estimates in this range and Cases 1 and 4 the least accurate. We conclude that using only three experimental points (at the s-values we used) to fit the three parameters of the VG equation is justified when representing water content data in the dry range for suctions above 30 cm. However, we do not recommend this configuration when the entire suction range from saturation to 15000 cm is of interest, in which case Cases 2 and 3 should be used. Case 3, furthermore, has the disadvantage of estimating water content very close to saturation with larger errors than when θ_s is fixed (Case 2).

Key words: van Genuchten equation, water retention curve, soil database

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