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Discussions

Interactive comment on "Predicting the soil water characteristic curve from the particle size distribution based on a pore space geometry containing slit-shaped spaces" *by* Chen-chao Chang and Dong-hui Cheng

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Dear Meskini-Vishkaee,

We thank you for your time and the constructive comments. The following are our responses to your comments. We expected more suggestions from you to improve our manuscript.

Regards

Cheng Dong-hui Hydrology professor

1. Since the relationship between the PSD and the pore size distribution (PoSD) is a fundamental element when predicting the SWRC from the PSD, first adjective of this study was to compare the estimated PoSD using traditional Method with the measured PoSD. The following comments and responding responses is about PoSD and PSD.

Comment a: This step includes i, estimated PoSD from PSD and ii, estimated PoSD from SWCC. The authors have to change subtitle "2) measuring the PoSD" in page 3, line 33 by "2) estimating the PoSD from SWCC".

Response: We will revise the subtitle mentioned above in revised manuscript.

Comment b: To estimate PoSD from PSD, called the traditional method as Arya model, here a proportionate relationship between pore size and associated particle diameter was used to calculate the equivalent pore diameter (Eqn. 2) because it was easy to use. This simplification may be a part of the estimation error of Arya and Paris (1891) model.

Response: The proportionate relationship between the pore size and the associated particle size was used to calculate the equivalent pore diameter and the suction head in our manuscript (Jensen et al., 2015). In order to evaluate the power of this calculation of suction head, we calculated suction head using proportionate relationship between the pore size and the associated particle size, and the water content calculation followed the way of Arya and Paris (1981) model (Arya and Paris, 1981). Based on the calculated suction and water content, the corresponding SWCC was predicted. Comparing with SWCC predicted using method in Mohammadi and Vanclooster (2011) (Figure 1) (Mohammadi and Vanclooster, 2011), we conclude that the method of calculated suction head using proportionate relationship between the pore size and the associated particle size not only could get a good predicted performance as the method in Mohammadi and Vanclooster (2011), but also was easy to use. In addition, this calculation method of suction head was difference from that in Arya and Paris (1891) model.

Figure 1: Predicted SWCCs using two methods and measured SWCC

Comment c: It is noted that estimation method of PoSD from SWCC is nearly similar to the estimation method of PoSD from PSD proposed by Mohammadi and Vanclooster (2010). Although, since SWCC is influenced both soil texture and structure, if soil organic carbon or clay content would be high, differences between estimated PoSD from SWCC and PSD become more. It must be mentioned that the prediction error of estimated SWCC from PSD is at dry range of SWCC (at high suction heads) that influences by soil texture (especially clay particles). Mohammadi and Meskini-Vishkaee (2012) attribute the methods error to the roughness of soil particles, high surface energy content of clay particles and, to the simplified pore geometric concepts that does not effectively reflect the pore geometry. It is better that the authors compare estimated PoSD from measured SWCC to estimated PoSD from PSD using similar method (use Mohammadi and vanclooster method as traditional method). Therefore, I think that these calculations have to add to this part of manuscript.

Response: We agree with the reviewer's viewpoint that the error of predicted SWCC from PSD is in dry range of SWCC (at high suction heads) that is influenced by soil texture (especially clay particles). The detailed description about this point of view has been presented in Section 2 "Basic descriptions" of our manuscript.

2. Tuller et al. (1999) and Or and Tuller (1999) proposed including the water films coating the pore walls and water in angular spaces of pores, in calculations of soil water content. Despite great scientific interest, the proposed approach for the derivation of SMC by Or and Tuller (1999) motivated by bundle of cylindrical tubes limitations, usually fails to describe experimental data in the intermediate soil water content range because of the low flexibility of the gamma distribution function used to characterize the PoSD (Lebeau and Konrad, 2010). In addition, the model is mathematically complex and furthermore needs specific surface area parameter which measurements and

estimations are often quite variable (Carter et al., 1986). The following two comments and responses are related to the pore geometry model and its parameters.

Comment a: The authors use pore geometry containing slit-shaped spaces proposed by Or and Tuller (1999), But they assumed that circle-shaped central pore connected to two slit-shaped spaces. Moreover, the estimated PoSD data were fitted using a modified logistic growth model (Eqn. 5).

Response: We use for reference the pore geometry containing slit-shaped spaces proposed by Or and Tuller (1999) (Or and Tuller, 1999), and the detailed information just like the description in comment a.

Comment b: Specific surface area (SSA) is a requirement parameter to obtain the values of α and β. The authors used a power equation with two fitting parameters (Eqn. 10) to estimate SSA proposed by Sepaskhah et al. (2010). Sepaskhah et al. (2010) used twenty soil samples from a depth of 0–30 cm were collected from different locations in Fars province, in the south of Iran to calibrate the power equation. In addition, a different set of data was used to validate the calibrated model. Their results indicated that in the range of around 20 up to 200 m2 g-1 the values of measured SSA were in quite a good agreement, while for SSA greater than 200 m2 g-1, the deviations increase distinctly. Moreover, Tuller and Or (2005) stated that the psychrometric approach for SSA determination should provide reliable values for natural soils with hydratable surface areas below 200 m2 g-1. They recommend using SWCC values for -10 MPa and lower (drier) with an effective Hamaker constant of -6$\times$10-20 J to predict SSA values. So, there are some ambiguities here, i. As respects higher SSA is related to finer texture soils that usually have underestimation problem of estimated SWCC from PSD, Indeed, I think use power model to estimate SSA cannot be useful to improve estimated SWCC in fine-textured soils. Page 9, line 4: the authors declared that "for the coarse-textured soil, the water content and prediction error of the SWCC changed relatively little for the same degree of change of the SSA". This is completely expected because not only there is not serious problem to estimate SWCC from PSD in coarse-textured soils, but also the value of estimated SSA using power equation is below 200 m2 g-1 for coarse-textured soils. ii. Is there any SSA measurement? Were the fitting parameters of power model controlled?

Response: The errors generated inevitably when calculating the specific surface area from a regressive power equation (Eq.(5)) (Sepaskhah et al., 2010); however, direct measurements of the specific surface area is difficult and the errors would also exist. Indeed, the specific surface area calculated using a power equation have relative large deviations for SSA greater than 200 m2 g-1. In our manuscript, initially the estimated SSA is combined with the measured SWCC to gain the value of parameter α and β, and then these parameters were used as input parameters in the predicting SWCC process hereafter. For the predicted SWCCs of fine-textured soils which calculated from the parameter α and β and estimated SSA, the errors from estimated SSA, to some extend, could been offset by the parameter α and β. Certainly, more effort should be directed to a more accurate method of SSA estimation. For fine-textured soils, the SWCC predicted using proposed method fit the measured data well and is better than that predicted using traditional method. Although the error generate when using power model to estimate SSA, the proposed method is useful to improve predicted SWCC in fine-textured soils. For coarse-textured soils, because the SSA of this soil is relative small, the water content and prediction error of the SWCC changed relatively little under the same proportional change of the SSA. We regret that we did not conduct SSA measurement. The power equation employed to predict SSA in our manuscript is an empirical equation and the parameters referred to Sepaskhah et al. (2010).

3. At the first step, the estimated PoSDs of 48 soil samples using SWRC were compared with the PoSDs calculated using PSD to identify the origins of the errors and their effects on the accuracy of the SWC and to calibrate the proposed model. Subsequently, 22 soil samples were also selected from UNSODA database to validate the model. The following three comments and responses are related to the data sets of the soil samples

Comment a: Please provide a Table involved some properties of selected samples for both calibration and validation data sets (e.g. max, min and average of clay content, organic matter, bulk density and. . .. . .for each soil textural class).

Response: The detailed information for both validation and calibration data sets are presented in Figure 2 and Figure 3, respectively.

Figure 2: Basic soil properties of 22 samples for the model validation.

Figure 3: Basic soil properties of 48 samples for the model calibration.

Comment b: About validation data set, Textural distribution of the 22 soil samples is shown in both Figure 5 and Table 3. This duplication is not necessary.

Response: Figure 5 exhibits more detailed content of clay, silt and sand particle for soil samples in model validation. The Figure 5 may be deleted in order to avoid duplication.

Comment c: As regards the most prediction error of traditional models is often related to soils with good structure or high clay content. Therefore, the authors have to use more fine-textured soils to validate their proposed model. In validation data set, only 4 soil samples had clay texture and more than 60 % of soil samples are coarse-textured soils. Please add more soil samples with higher clay content and organic matter to the validation data set.

Response: The absolute errors of predicted water content to measured water content using traditional models for fine-textured is higher than that for coarse-textured soil. However the relative errors of both fine-textured and coarse-textured soils cannot be ignored. We will add some new soil samples in order to fully validate the predicted model.

4. The following comment is related to the calibration and validation of proposed model.

Comment: In page 8, line 19-21: the authors stated that "These improvements are mainly attributed to the pore model containing slit-shaped spaces, demonstrating that this pore model is better for predicting the SWC from the PSD than the concept of a bundle of cylindrical tubes". This simplification (concept of a bundle of cylindrical tubes) is introduces as major source of error in the SWCC predictor models using PSD. After that, some studies have attempted to improve the water content calculation approach by attributing model errors to both a simplified pore geometry and an incomplete desorption of residual water in the soil pore within the high matric suction head range. Therefore, I think the authors have to compare proposed model to other models except Arya and Paris (1981), such as Mohammadi and Meskini-Vishkaee (2012) or Meskini-Vishkaee et al. (2014) or other models. The comparison between the performance of these models and parameter needs can be more helpful. Please expand discussion part and state the result of proposed model for both data sets (calibration and validation) in more detailãĂĆ

Response: The traditional and the proposed model used for the SWCC prediction are described in our manuscript in detail. Therefore we did not add the calculation method and the prediction results of other improved model to avoid the excessive content. But we agree that it will improve the manuscript if the performances comparison between the proposed model and other improved models were added. Thus, we will compare our model with the improved model in Meskini-Vishkaee et al. (2014) (Meskini-Vishkaee et al., 2014) and add relative predicted results and discussions.

References

Arya, L. M., and Paris, J. F.: A physicoempirical model to predict the soil moisture characteristic from particle-size distribution and bulk density, Soil Science Society of America Journal, 45, 1023-1030, doi:10.2136/sssaj1981.03615995004500060004x, 1981. Jensen, D. K., Tuller, M., Jonge, L. W. D., Arthur, E., and Moldrup, P.: A new Two-Stage Approach to predicting the soil water characteristic from saturation to oven-dryness, Journal of Hydrology, 521, 498-507, doi: 10.1016/j.jhydrol.2014.12.018, 2015. Meskini-vishkaee, F., Mohammadi, M. H., and Vanclooster, M.: Predicting the soil moisture retention curve, from soil particle size distribution and bulk density data using a pack-

ing density scaling factor, Hydrology & Earth System Sciences, 18, 4053-4063, doi: 10.5194/hess-18-4053-2014, 2014. Mohammadi, M. H., and Vanclooster, M.: Predicting the soil moisture characteristic curve from particle size distribution with a simple conceptual model, Vadose Zone Journal, 10(2), 594-602, doi:10.2136/vzj2010.0080, 2011. Or, D., and Tuller, M.: Liquid retention and interfacial area in variably saturated porous media: Upscaling from singleâĂŘpore to sampleâĂŘscale model, Water Resources Research, 35, 3591-3605, doi:10.1029/1999WR900262, 1999. Sepaskhah, A. R., Tabarzad, A., and Fooladmand, H. R.: Physical and empirical models for estimation of specific surface area of soils, Archives of Agronomy & Soil Science, 56, 325-335, doi: 10.1080/03650340903099676, 2010.

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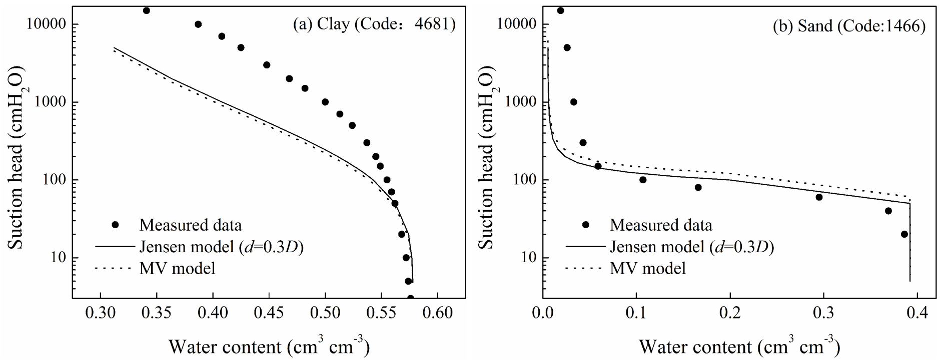

Fig. 1.

Figure 2: Basic soil properties of 22 samples for the model validation.

Soil texture	Number of soil		Clay (%)	Sand (%)	ρ_b (g m^{-3})
	4	Min	43	5.4	1.1
Clay		Max	57	32	1.5
		Average	51	16.5	1.3
Loamy	2	Min	16.5	47.9	1.41
		Max	29.2	43.6	1.45
Loamy sand	5	Min	1.7	75.5	1.37
		Max	7.3	85.2	1.59
		Average	4.9	81	1.46
Sand	5	Min	1.1	90.1	1.46
		Max	4.4	97.5	1.58
		Average	2.3	93.4	1.53
Sandy loam	2	Min	11.4	56.8	1.44
		Max	12.6	65.7	1.46
Sandy clay loam	4	Min	9.8	28	1.21
		Max	26	41	1.53
		Average	21	35.5	1.36

Fig. 2.

Figure 3: Basic soil properties of 48 samples for the model calibration.

Soil texture	Number of soil		Clay (%)	Sand (%)	ρ_b (g m^{-3})
Clay	9	Min	41.5	6.1	1.08
		Max	58.2	36	1.64
		Average	50.2	14.1	1.29
Loam	4	Min	14	42	1.36
		Max	23	67	1.63
		Average	17.3	50.5	1.46
Loamy sand	10	Min	3	76.2	1.32
		Max	10.4	89.4	1.6
		Average	6.1	83.2	1.46
Sand	16	Min	0.7	89.6	1.41
		Max	4.6	98.9	1.7
		Average	2.5	93.4	1.55
Sandy clay loam	1		2.7	62.5	1.7
Sandy loam	3	Min	10.5	64.9	1.27
		Max	19.4	76.3	1.7
		Average	15	68.8	1.50
Silt loam	5	Min	10.5	21	1.49
		Max	15.7	34.8	1.56
		Average	12.6	26.5	1.52

Fig. 3.