Hydrol. Earth Syst. Sci. Discuss., 4, S333–S341, 2007
www.hydrol-earth-syst-sci-discuss.net/4/S333/2007/

Hydrology and Earth System Sciences Discussions

Interactive comment on "SWRC fit – a nonlinear fitting program with a water retention curve for soils having unimodal and bimodal pore structure" *by* K. Seki

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Received and published: 4 June 2007

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I appreciate the referees' comments, which improved the submitted paper to HESSD. The manuscript was carefully revised according to the suggestions made by the referees for the submission to HESS journal. Please find my detailed responses to the comments below which explains how the revised manuscript was prepared.

Replies to the general comments

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Interactive Discussion
Discussion Paper

This paper contributes to the scientific community in two aspects, which were acknowledged by all the referees. The first contribution is that it presents a novel computer code for fitting parameters of soil hydraulic functions to measured soil water retention data. The second contribution is that it introduces a novel multi-modal soil hydraulic model.

As for the first contribution, as there already exists the computer code of the same purpose, RETC, the novelty of this code relies on the algorithm for an automatic calculation of initial parameter guesses. Referee #1 stated that this is a rather practical aspect and of no direct scientific meaning. Referee #3 stated that it is the users' responsibility to give a good set of initial estimate and not of direct scientific interest. However, Referee #2 acknowledged that although the computer code may have some limitation in the use of scientific data evaluation, it is of interest to many HESS readers and is a helpful tool for a quick and easy fitting of soil water retention data to soil hydraulic models, and therefore, the availability of the code should be communicated to the scientific community. I, as an author, think that the originality of this code lies in the algorithm of successive estimate of initial parameters, and the importance of this work is that the algorithm was actually implemented, verified with various soil hydraulic data, and a quick and easy fitting tool was made available.

The second point is that the new model, the linear superposition of two or more unimodal Kosugi model. Referee #1 stated that a linear superposition of two or more unimodal retention models is common and not new. Actually, in this paper, the commonly used Durner's model, which is a linear superposition of van Genuchten's model, is also introduced and the author does not claim that the idea of superposition of unimodal retention model itself is novel. New about this paper is the selection of the unimodal model to be superposed, as Referee #2 and #3 acknowledged. This approach is theoretically simple because the pore-size distribution is assumed to be multimodal log-normal function. Referee #2 stated that the author presents a novel multi-modal soil hydraulic model, which is a superposition of the uni-modal Kosugi model. Referee

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#3 stated that novel about the paper is the introduction of a bi-modal water retention function of Kosugi's log-normal pore-size distribution model by superposition, following Durners approach.

As the code introduced in this paper is intended to be a quick and easy tool for the fitting, some scientists may feel that he needs more precise information about the fitting; Referee #2 argued that the code does not provide confidence intervals or parameter correlations coefficients, and Referee #3 pointed out several limitations of this tool that limit the scientific use. In the revised version of SWRC Fit, prepared for the publication in HESS, some advanced features for scientific use were implemented.

The advanced features that were implemented in the revised version were, in the order of the comment of Referee #3, (i) to give a weight to the individual data points; (ii) to fix parameters for saturated water content, not only for residual water content; (iii) to make the default setting disallowing the residual water content having negative value; (iv) to make the "advanced mode" option which gives correlation matrix and standard deviation of parameters (also suggested by Referee #2).

However, following limitation still remains; (v) to make control on the initial parameter estimates by users; automatic estimation of the initial parameters is the originality of this software, and therefore I would keep it as is. (vi) to include other measurements of hydraulic parameters, e.g., hydraulic conductivity, and perform a simultaneous fit; this feature would be useful if implemented and therefore I will consider developing it in the future release of this software, but not at the right moment.

Referee #1, #2 and #3 have pointed out that this paper is redundant, presenting unnecessary information. Therefore some parts of the paper in HESSD was removed or shortened to focus on the two scientific contributions mentioned above. As Referee #1 suggested, description of the usage of the software was moved to user's manual in a supplementary file. Some textbook information and hydraulic conductivity model was omitted. Here is a list of the deleted or shortened part of the revised text.

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Referee #3: P410 L17 - P411 L5: Deleted.

Referee #1: P415 L18 - P417 L9: Moved to user's manual.

Referee #1: P418 L12-28: Moved to user's manual.

Referee #3: P419 L26 - P420 L21: Deleted.

Referee #1: P421 L1-13: Deleted.

Referee #3: Table 1: analytical solutions of hydraulic conductivity models was deleted.

Referee #1 and #2: P411 L13 - P412 L20: Description of Kosugi's model was shortened and focused on the derivation of the new model, as suggested by Referee #2.

Referee #1: P414 L3-11: Equation 15 can be directly derived from Equation 11, as the referee suggested. However, I would like to derive Equation 15 from Equation 13, i.e., the multimodal log-normal pore-size distribution. This derivation may look obvious or redundant, but I would like to record this derivation process. As the derivation of LN model was omitted, the derivation process of the proposed BL model was written in more detail.

Referee #1 also suggested state of the art method of treating the measured water contents as the integral of the soil water distribution over the column height. This method is mentioned in the Theory section (P414 L18).

Replies to specific comments by Referee #1

P408 L2-5: "fitting a soil water retention curve to a certain function, i.e., a soil hydraulic model" was rewritten as " fitting a soil water retention function, i.e., a soil hydraulic model, to measured data."

P408 L11-14: "The program can be executed directly from ... is included in the electronic supplement of this paper" was deleted from the abstract.

P408 L15-17: "After comparing the root mean square error of the unimodal models, the

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van Genuchten and Kosugi's models were better than the Brooks and Corey model" was deleted from the abstract, as this result is not very surprising although important.

P408 L24-25: z was defined.

P410 L24: This paragraph was deleted.

P411 L3-4 Analytical solution for the multimodal van Genuchten model (Priesack and Durner, 2006) is a very interesting work. However this part was deleted because hydraulic conductivity estimation is not of relevance for the new tool presented in this paper.

P413 L16: Corrected to $n_i > 1$.

P413 L20 - P413 L2: Shortened.

P417 L19: "was determined by fitting many VG curves to LN curves" was rewritten as "This relationship was determined by fitting LN models to many VG curves of ..."

P418 L1-3: It was noted that the criteria of 1 percent is arbitral.

P419 L26 - P420 L21: The description of modified van Gnuchten and the original Kosugi model was deleted.

P423 L1-5: This paragraph was deleted.

Equation 1: Richard's equation was not directly analyzed in this paper but it was not deleted because it explains why obtaining soil hydraulic parameters is important.

Equation 3: The whole paragraph was deleted.

Table 1: The analytical solutions for k_r were deleted.

Fig. 6 to Fig. 8 were corrected.

Replies to technical corrections by Referee #1

P408 L8: "... model propose in this..." was rewritten as "... model proposed in this..."

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Interactive Comment

P410 L6: "In the Table 1 ..." was rewritten as "... in Table 1..."

P410 L16: "... the BC model is identical to another famous model by Campbell (1974)." was rewritten as "... the BC model is identical to the model of Campbell (1974)."

P410 L23: This part was deleted.

P413 L9-10: "... the large pore is that between the aggregates and the small pore is that ..." was rewritten as "... the large pores are that between the aggregates and the small pores are that ...". The whole explanation of Figure 1 was moved to Results and Discussion section.

P413 L14: "In Table 1, k is the number ..." was rewritten as "k is the number ..."

P414 L3: "The Pore-size distribution ..." was rewritten as "The pore-size distribution ..."

P423 L12: "... BC models, .." was rewritten as "... BC model, ..."

Replies to specific comments by Referee #2

The theory section was shortened. The derivation of the log-normal model of Kosugi (1996) was shortened and the derivation of the novel soil hydraulic model was expanded. Fig. 6 to 8 were merged but Fig. 9 to 11 were not merged. The structure of the manuscript was improved, as suggested by the Referee. The results of parameter exercises are presented in the results section, and the datasets for verification was described in the methods section. The results section was renamed as "Results and Discussion". The conclusion section was rewritten.

Replies to technical corrections by Referee #2

P408 L3: "fitting a soil water retention curve to a certain function, i.e., a soil hydraulic model" was rewritten as " fitting a soil water retention function, i.e., a soil hydraulic model, to measured data."

P408 L4-5: "which performs nonlinear fitting of soil water retention curves to 5 models"

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was rewritten as "which performs nonlinear fitting of 5 soil hydraulic models".

P408 L6-8: Five models were numbered.

P408 L8: "propose in this study" was rewritten as "proposed in this study."

P408 L9: "This program automatically determines all the necessary conditions for the nonlinear fitting, such as the initial estimate of the parameters, ..." was rewritten as "This program automatically determines the initial estimate of the parameters and the fractional increment of parameters for numerical partials, ..."

P408 Eq. 1: Matric potential form of the Richard's equation was used because it explicitly has $\theta(h)$ function that is directly used in this study.

P409 L1-2: "... and the unsaturated hydraulic conductivity, K(h)" was rewritten as "... and the unsaturated hydraulic conductivity function, K(h)"

P409 L1: "critical" was rewritten as "crucial"

P409 L6: The symbol $\theta(h)$ was already introduced and therefore deleted.

P409 L15-16: "it is the users' responsibility to give a good set of initial parameters to make the calculation" was rewritten as "it is the users' responsibility to give a reasonable set of initial estimates"

P409 L18-20: "it would be more convenient if the program were to be responsible for making the initial estimate from the retention data and users would not have to input the initial estimate" was rewritten as "it would be more convenient if the program would compute and initial guess for each parameter based on the measured soil water retention data"

P410 L7: S_e was defined as effective soil water content.

P415 L3: "compartments" was rewritten as "components"

P419 L4: "... for the sample data ..." was deleted.

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Replies to specific comments by Referee #3

P408 L3: "fitting a soil water retention curve to a certain function, i.e., a soil hydraulic model" was rewritten as "fitting a soil water retention function, i.e., a soil hydraulic model, to measured data."

P408 L24: The variables z and t were defined.

P411 L4: Priesack and Durner (2006) is a very interesting work. However this part was deleted because hydraulic conductivity function was not analyzed in this paper.

P411 L5 The description of hydraulic conductivity function was deleted because it is not analyzed in this study.

P411 L19-20 r, r_m and σ^2 were defined.

P413 L16-17: As defined in Table 1, subscript i denotes each mode and the subscript k denotes the modality. Therefore they are different parameters.

P417 L13-14: The way of determining the initial estimate of the residual and saturated water content was described.

P417 L20: Fitting procedure of LN models to VG curves was not very well documented, and therefore the result is shown as a new figure.

P417 L22: The way how the tool selects the data points for the analysis of DB parameters was more precisely described.

P419 L14: The base of the log-transformation was described.

P421 L6-7: This paragraph was deleted.

P421 L23-28: The sentence "By looking at the parameter correlations and the standard deviation, additional information on deciding which model is more appropriate might be obtained." was added.

P425 L13: Caption of Table 1 was improved.

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Fig. 6-8: These Figures were revised.

Replies to technical corrections by Referee #3

P409 L13: "... analyzes the soil water retention curve and unsaturated hydraulic conductivity," was rewritten as "... analyzes the soil water retention curve and unsaturated hydraulic conductivity, amongst others,".

P409 L18: The sentence beginning with "the program were" was rewritten according to the suggestion by Referee #2.

P410 L13: "the pores are entrapped with air" was rewritten as "air is entrapped in the pore space"

P411 L8: Corrected to "The constraint ... was imposed ..."

P422 L14: "There are no data points in these points" was rewritten as "There are no measurements between these two data points".

References

Priesack, E., and W. Durner (2006) Closed form expression for the multi-modal unsaturated conductivity function, Vadose Zone J., 5, 121-124.

Interactive comment on Hydrol. Earth Syst. Sci. Discuss., 4, 407, 2007.