Rosetta:

A computer program for estimating soil hydraulic parameters with hierarchical pedotransfer functions

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Abstract

Mathematical models have become increasingly popular in both research and management problems involving flow and transport processes in the subsurface. The unsaturated hydraulic functions are key input data in numerical models of vadose zone processes. These functions may be either measured directly or estimated indirectly through prediction from more easily measured data based using quasi-empirical models. Rosetta V1.2 is a Windows 95/98/XP program to estimate unsaturated hydraulic properties from surrogate soil data such as soil texture data and bulk density. Models of this type are called pedotransfer functions (PTFs) since they translate basic soil data into hydraulic properties. Rosetta can be used to estimate the following properties:

- Water retention parameters according to van Genuchten (1980)
- Saturated hydraulic conductivity
- Unsaturated hydraulic conductivity parameters according to van Genuchten (1980) and Mualem (1976)

Detailed description of the hydraulic functions Rosetta offers five PTFs that allow prediction of the hydraulic properties with limited or more extended sets of input data. This hierarchical approach is of a great practical value because it permits optimal use of available input data. The models use the

following hierarchical sequence of input data

- Soil textural class
- Sand, silt and clay percentages
- Sand, silt and clay percentages and bulk density
- Sand, silt and clay percentages, bulk density
  and a water retention point at 330 cm (33 kPa).
- Sand, silt and clay percentages, bulk density
  and water retention points at 330 and 15000 cm (33 and 1500 kPa)

The first model is based on a lookup table that provides class average hydraulic parameters for each USDA soil textural class. The other four models are based on neural network analyses and provide more accurate predictions when more input variables are used. In addition to the hierarchical approach, we also offer a model that allows prediction of the unsaturated hydraulic conductivity parameters from fitted van Genuchten (1980) retention parameters (Schaap and Leij, 1999; Schaap et al. 2001). This model is also used in the hierarchical approach such that it automatically uses the *predicted* retention parameters as input, instead of measured (fitted) retention parameters.

All estimated hydraulic parameters are accompanied by uncertainty estimates that permit an assessment of the reliability of Rosetta's predictions. These uncertainty estimates were generated by combining the neural networks with the bootstrap method (see Schaap and Leij (1998), Schaap et al. (1999), Schaap et al. (2001) for more information).

Data input and output

Rosetta is based on ACCESS-97 database tables which allow efficient handling and lookup of small and large volumes of data. Data can be either manually entered or read from ASCII files. The maximum amount of samples (records) that Rosetta can handle is limited by the available hard disk space. Estimated hydraulic properties can be exported in ASCII files and used in other programs. ACCESS-97 is not required to run Rosetta; however, ACCESS-97 can be used to manage Rosetta's predictions in a larger project, provided that the tables created by Rosetta are not altered.

Downloading and installing Rosetta

The compressed ROSETTA.EXE file can be downloaded HERE.

Please follow these steps:

- Download ROSETTA.EXE (approximately 7 MB), store this file in a temporary folder and run it from the Windows Start menu (Start, Run).

- Go to the Start menu again, and run SETUP.EXE from the same folder used for ROSETTA.EXE. This will install Rosetta on your PC.

- Important: go the folder where Rosetta was installed (usually “\windows\program files\rosetta”) and run dao350.exe (Start, Run). Click “OK” or “continue” when asked to insert a disk. This step is needed to install database objects for Rosetta.

  Rosetta will take up less than 10 MB of disk space when installed.

Help system and tutorials

Rosetta contains extensive help files that explain how to use the various menu options and screens. The help system also contains two tutorials that illustrate most functions in Rosetta. Furthermore, the help system contains extensive information about the background of Rosetta (data used for calibration, calibration results, neural networks and the bootstrap method).

ROSETTA Hydraulic Functions

The present version of Rosetta is capable of predicting van Genuchten (1980) water retention and unsaturated hydraulic conductivity parameters, as well as of providing estimates of the saturated hydraulic conductivity, K_s. The van Genuchten water retention function is given by:

$$\theta(h) = \theta_r + \frac{\theta_s - \theta_r}{[1 + (\alpha h)^n]^{1-1/n}}$$

where $\theta(h)$ represents the water retention curve defining the water content, θ (cm^3/cm^3), as a function of the soil water pressure head h (cm), θ_r and θ_s (cm^3/cm^3) are residual and saturated water contents, respectively, while α (1/cm) and n are curve shape parameters. This equation can be rewritten to yield the relative saturation, S_e:

$$S_e = \frac{\theta(h) - \theta_r}{\theta_s - \theta_r} = [1 + (\alpha h)^n]^{1/n-1}$$

This equation is used in conjunction with the pore-size distribution model by Mualem (1976) to yield the van Genuchten-Mualem model (van Genuchten, 1980):

$$K(S_e) = K_o S_e^L \{1 - [1 - S_e^{n/(n-1)}]^{1-1/n}\}^2$$

in which K_o is the matching point at saturation (cm/day) and similar, but not necessarily equal, to the saturated hydraulic conductivity, K_s. The parameter L (-) is an empirical pore tortuosity/connectivity parameter that is normally assumed to be 0.5 (*Mualem*, 1976). Rosetta predicts L which will be negative in most cases. Although this leads to some theoretical complications, negative L values give far better results (cf., Kosugi, 1999; Schaap and Leij, 1999).

ROSETTA Class Average Hydraulic Parameters

The table below gives class-average values of the seven hydraulic parameters for the twelve USDA textural classes. Effectively, this table represents the first model of the hierarchical sequence. For the θ_r, θ_s, ,α n and K_s parameters, the values have been generated by computing the average values for each textural class. For K_o and L the values were generated by inserting the class average values of θ_r, θ_s, α , n into Model C2 (see Rosetta's help file). This means that K_o and L are based on predicted parameters and may not be very reliable. The values in parentheses give the one standard deviation uncertainties of the class average values.

Texture Class	N	-- θ_r -- cm^3/cm^3		-- θ_s -- cm^3/cm^3		-- log(α) -- log10(1/cm)		-- log(n) -- log10		-- K_s -- log(cm/day)		-- K_o -- log(cm/day)		-- L --	
Clay	84	0.098	(0.107)	0.459	(0.079)	-1.825	(0.68)	0.098	(0.07)	1.169	(0.92)	0.472	(0.26)	-1.561	(1.39)
C loam	140	0.079	(0.076)	0.442	(0.079)	-1.801	(0.69)	0.151	(0.12)	0.913	(1.09)	0.699	(0.23)	-0.763	(0.90)
Loam	242	0.061	(0.073)	0.399	(0.098)	-1.954	(0.73)	0.168	(0.13)	1.081	(0.92)	0.568	(0.21)	-0.371	(0.84)
L Sand	201	0.049	(0.042)	0.390	(0.070)	-1.459	(0.47)	0.242	(0.16)	2.022	(0.64)	1.386	(0.24)	-0.874	(0.59)
Sand	308	0.053	(0.029)	0.375	(0.055)	-1.453	(0.25)	0.502	(0.18)	2.808	(0.59)	1.389	(0.24)	-0.930	(0.49)
S Clay	11	0.117	(0.114)	0.385	(0.046)	-1.476	(0.57)	0.082	(0.06)	1.055	(0.89)	0.637	(0.34)	-3.665	(1.80)
S C L	87	0.063	(0.078)	0.384	(0.061)	-1.676	(0.71)	0.124	(0.12)	1.120	(0.85)	0.841	(0.24)	-1.280	(0.99)
S loam	476	0.039	(0.054)	0.387	(0.085)	-1.574	(0.56)	0.161	(0.11)	1.583	(0.66)	1.190	(0.21)	-0.861	(0.73)
Silt	6	0.050	(0.041)	0.489	(0.078)	-2.182	(0.30)	0.225	(0.13)	1.641	(0.27)	0.524	(0.32)	0.624	(1.57)
Si Clay	28	0.111	(0.119)	0.481	(0.080)	-1.790	(0.64)	0.121	(0.10)	0.983	(0.57)	0.501	(0.27)	-1.287	(1.23)
Si C L	172	0.090	(0.082)	0.482	(0.086)	-2.076	(0.59)	0.182	(0.13)	1.046	(0.76)	0.349	(0.26)	-0.156	(1.23)
Si Loam	330	0.065	(0.073)	0.439	(0.093)	-2.296	(0.57)	0.221	(0.14)	1.261	(0.74)	0.243	(0.26)	0.365	(1.42)

References

Kosugi, K. 1999. General model for unsaturated hydraulic conductivity for soils with lognormal pore-size distribution. Soil Sci. Soc. Am. J. 63:270-277.

Mualem, Y. 1976. A new model predicting the hydraulic conductivity of unsaturated porous media. Water Resour. Res. 12:513-522.

Schaap, M.G. and W. Bouten. 1996. Modeling water retention curves of sandy soils using neural networks. Water Resour. Res. 32:3033-3040.

Schaap, M.G., Leij F.J. and van Genuchten M.Th. 1998. Neural network analysis for hierarchical prediction of soil water retention and saturated hydraulic conductivity. *Soil Sci. Soc. Am. J.* 62:847-855.

Schaap, M.G., and F.J. Leij, 1998. Database Related Accuracy and Uncertainty of Pedotransfer Functions, *Soil Science* 163:765-779.

Schaap, M.G., F.J. Leij and M. Th. van Genuchten. 1999. A bootstrap-neural network approach to predict soil hydraulic parameters. *In*: van Genuchten, M.Th., F.J. Leij, and L. Wu (eds), Proc. Int. Workshop, *Characterization and Measurements of the Hydraulic Properties of Unsaturated Porous Media*, pp 1237-1250, University of California, Riverside, CA.

Schaap, M.G., F.J. Leij, 1999, Improved prediction of unsaturated hydraulic conductivity with the Mualem-van Genuchten, Submitted to *Soil Sci. Soc. Am. J.*

Schaap, M.G., F.J. Leij, and M. Th. van Genuchten, 2001. Rosetta: a computer program for estimating soil hydraulic parameters with hierarchical pedotransfer functions. Journal of Hydrology, 251:163-176.

van Genuchten, M.Th. 1980. A closed-form equation for predicting the hydraulic conductivity of unsaturated soils. Soil Sci. Am. J. 44:892-898.