

Short communication

## SOILPAR 2.00: software to estimate soil hydrological parameters and functions

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### Abstract

SOILPAR 2 is a program for estimating soil parameters. It allows: (1) storing soil data in a georeferenced database, (2) computing estimates of soil hydrological parameters using 15 procedures, (3) comparing the estimates against measured data using both statistical indices and graphics, and (4) creating maps using the ESRI format. An interface to/from Excel and CropSyst is provided. Eleven methods estimate one or more of the following characteristics: soil water content at predefined soil matrix tension, saturated hydraulic conductivity, and bulk density. Three methods estimate the parameters of well-known soil water retention functions (Brooks-Corey, Hutson-Cass, van Genuchten), and one estimates both saturated soil hydraulic conductivity and the soil water retention curve parameters (Campbell). The software runs under Windows 98/NT/2000/XP and is freely downloadable via internet.

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### 1. Introduction

Soil hydrological parameters are required in simulation model applications of cropping systems, ground water dynamics, water erosion, soil conservation and other systems/processes. Since a long time (e.g. Nielsen et al., 1986) there has been a remarkable interest in low cost and quick methods to estimate soil hydrological parameters from commonly available soil data. Such estimates are

made with pedotransfer functions (PTF) which are predominantly based on empirical relationships, so their validity is strictly related to the data set used to develop the functions (Wösten et al., 1999). Moreover, many pedotransfer procedures are available and can produce substantially different estimates. Therefore, users have a difficult task in selecting the more appropriate PTF for their application.

Some tools have been developed to estimate soil hydraulic properties. Several of them run in a web browser, but offer only few methods of estimation and limited capacity for soil data management; examples of such software are Pedon-E (Ungaro et al., 2001), available at [http://www.area.fi.cnr.it/iges/pedone/Pedon\\_introd.htm](http://www.area.fi.cnr.it/iges/pedone/Pedon_introd.htm), and SWLIMITS

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(Ritchie et al., 1999, Suleiman and Ritchie, 2001), available at <http://nowlin.css.msu.edu>. An example of stand alone software is Rosetta (Schaap et al., 1999), which uses a neural network and bootstrap approach, respectively for prediction and uncertainty analysis, and SOILPROP (Environmental System and Technologies, 1990), based on a single, physically based method.

SOILPAR overcomes the difficulties of these tools with the following objectives:

- a) To offer a georeferenced database structure to manage physical, chemical and hydrological soil data;
- b) To implement several methods to estimate soil hydrological parameters, and two methods for estimating bulk density of the soil;
- c) To allow comparing different methods against measured data.

## 2. Software description

SOILPAR 2.00 is a significant evolution of version 1.1, made available during 1996 (Donatelli et al., 1996). It runs under MS Windows (98/NT/2000) and it provides easy access to several pedotransfer methods via a user friendly interface. Software components are shown in Fig. 1. The interface (Fig. 2) allows the users to easily manipulate inputs, load selected data, calculate pedotransfer and evaluation statistics, display graphics and maps, and export outputs to both CropSyst (Stöckle et al., 2003) and MS Excel formats. The program uses a database structure (MS Access format) which allows storing soil profile descriptions. Input and storage of physical, hydrological, and chemical parameters involved in pedotransfer use (Table 1) is allowed up to ten layers per profile. The database also allows storing site specific information (description, soil classification, latitude, longitude, altitude, slope, and user notes). The US Department of Agriculture (USDA), particle size distribution (PSD) classification schemes are used, with 3 (sand, silt, clay) or 7 (very coarse sand, coarse sand, medium sand, fine sand, very fine sand, silt, clay) texture classes

subdivision. The program also allows importing data from CropSyst files and MS Excel spreadsheets (in the latter case either from files or via copy and paste). SOILPAR can be installed either as a stand alone application or integrated as an application in the CropSyst software suite.

### 2.1. Summary of analysis capabilities

The program provides 15 procedures to estimate soil parameters. When possible, we used the same implementation of already existing software, and consequently we indicated the methods with the name already used in these software (Table 1).

The pedotransfer procedures are classified as:

- a) point pedotransfer, which estimates some specific points of interest of the water retention characteristic and/or saturated hydraulic conductivity. Two of these methods also estimate bulk density. They are summarized in Table 1.
- b) function pedotransfer, which estimates the parameters of retention functions. Four methods are implemented: Rawls and Brakensiek (1989), to estimate the Brooks and Corey (1964) function parameters; Vereecken et al. (1989), to estimate the van Genuchten (1980) function parameters; Campbell (1985) to estimate the Campbell function parameters (Campbell, 1974); Mayr and Jarvis (1999), to estimate the parameters of the Hutson and Cass (1987) modification of the Campbell function. All these methods require as input PSD and bulk density. The Mayr and Jarvis, and Vereecken et al. methods also require organic carbon content.

Estimates can be saved in the database. If measured data are available, the coupling of the estimated values and the measured ones is possible, thus allowing an evaluation of method performance. Such evaluation can be run using either all data or a subset selected on the basis of user specified soil types (by selecting soil groups in the soil textural triangle). Single couples estimated–measured data can be excluded from the analysis. The data couples and the relevant statistics pro-

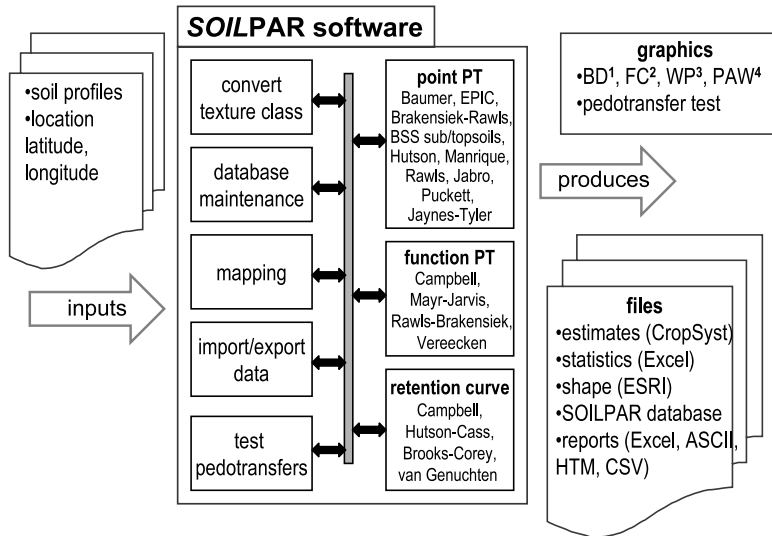


Fig. 1. Components of the program *SOILPAR*. <sup>1</sup>Bulk density; <sup>2,3</sup>soil water content at field capacity and wilting point; <sup>4</sup>plant available water.

Soil Parameters Estimate

File Edit Method Graph Validation Reports ?

Soil data - standard parameters

FR0\_270 Select profile method RAWLS

RAWLS method estimates: BD, WP, FC 06-26-2002 21:52:55 RAWLS

parameters measured	M.U.	L1	L2	L3	L4	L5	L6	L7	L8	L9	L10
depth from surface	(m)	0.45	0.60	1.00	1.10	1.30					
bulk density	(t/m <sup>3</sup> )	1.23	1.23	1.36	1.29	1.32					
wilting point	(m/m)	0.22	0.15	0.12	0.15	0.14					
field capacity	(m/m)	0.26	0.21	0.22	0.27	0.27					
very coarse sand content	(%)	4.89	7.89	8.83	6.76	7.14					
coarse sand content	(%)	4.89	7.89	8.83	6.76	7.14					
sand	(%)	4.89	7.89	8.83	6.76	7.14					
fine sand	(%)	6.46	10.43	11.67	8.94	9.44					
very fine sand	(%)	4.89	7.89	8.83	6.76	7.14					
silt content	(%)	49.00	41.00	40.00	46.00	46.00					
clay content	(%)	25.00	17.00	13.00	18.00	16.00					
coarse fragment content	(%)										
organic carbon	(%)	1.70	0.80	0.50	0.20	0.10					

parameters estimated	M.U.	L1	L2	L3	L4	L5	L6	L7	L8	L9	L10
bulk density	(t/m <sup>3</sup> )	1.49	1.57	1.60	1.56	1.57					
wilting point	(m/m)	0.17	0.12	0.09	0.12	0.11					
field capacity	(m/m)	0.33	0.27	0.25	0.28	0.27					
saturated hydraulic conductivity	(mm/h)										
SWC at 20 (-J/kg)	(m/m)										
SWC at 33 (-J/kg)	(m/m)										
SWC at 60 (-J/kg)	(m/m)										
SWC at 100 (-J/kg)	(m/m)										
SWC at 200 (-J/kg)	(m/m)										
SWC at 1000 (-J/kg)	(m/m)										
SWC at 1500 (-J/kg)	(m/m)										
Campbell a	(-J/Kg)	3.47	2.03	4.01	3.38	3.79					
Campbell b	(adim.)	5.94	4.81	3.76	4.55	4.21					

Data Data graph Validation Soil type selection Options

Fig. 2. Screen of the data entry procedure.

Table 1  
Point pedotransfer methods available in *SOILPAR*

Method	Variables requested	parameter estimated	Source
Baumer	PSD, OC <sup>a</sup>	BD <sup>b</sup> , FC <sup>c</sup> WP <sup>d</sup>	EPIC/ASW
Brakensiek/Rawls	PSD, OC BD	SWC <sup>e</sup>	LeachM (Hutson and Wagenet, 1992)
British Soil Survey subsoil	PSD, OC BD	SWC	LeachM (Hutson and Wagenet, 1992)
British Soil Survey topsoil	PSD, OC BD	SWC	LeachM (Hutson and Wagenet, 1992)
EPIC	PSD, BD	FC WP	EPIC/ASW
Hutson	PSD, BD	SWC	LeachM (Hutson and Wagenet, 1992)
Manrique	PSD; BD	FC WP	EPIC/ASW
Rawls	PSD	BD, FC WP	EPIC/ASW
Jabro	PSD, BD	Ks <sup>f</sup>	Jabro (1992)
Jaynes-Tyler	PSD, BD	Ks	Jaynes and Tyler (1984)
Puckett	PSD	Ks	Puckett et al. (1985)
Campbell	PSD, BD	Ks	Campbell (1985)

All methods can be applied using at least three classes PSD. The Campbell method is the only one which can take advantage of the seven class PSD.

<sup>a</sup> OC, organic carbon.

<sup>b</sup> BD, bulk density.

<sup>c</sup> FC, field capacity.

<sup>d</sup> WP, wilting point.

<sup>e</sup> SWC, soil water contents at several tension.

<sup>f</sup> Ks, Hydraulic saturated conductivity.

duced can be saved in multi-sheet MS Excel files for further analysis to be made with tools such as IRENE (Fila et al., 2003).

## 2.2. Utilities

To allow fitting the parameters of the water retention functions, in case measured data of water content at different soil water matrix potential are available, a procedure for non-linear fitting is implemented. This procedure uses the simplex method, modified in order to allow using bounds on the parameters, to avoid physical inconsistencies in the fitted parameter values. The non-linear fitting utility allows also an estimation of the retention function parameters, for those point pedotransfers that estimate water contents in more than 3 points.

A utility allows for a conversion from a non-USDA PSD classification system to the USDA one, based on the assumption of a log-normal distribution of particle size; the classification of PSD following ISSS (International Society of Soil Science, with 3 and 4 classes), BSS (British Soil

Service with 3 and 4 classes) or any user-defined scheme with 3 or 5 classes can be converted to the USDA standard.

A mapping utility allows: (1) showing soil profile locations on a map, (2) retrieving the profile characteristics, and (3) creating an ESRI ArcView/ArcInfo shape file of the profiles shown. Other utilities to manage the data base (back-up, update etc.) are also available.

## 2.3. Ongoing developments

The software has a modular structure that allows an easy implementation of new pedotransfer methods. Saxton et al. (1986) and the method based on the Hypres (HYdraulic PROperties of European Soil) database (Wösten et al., 1999) are being tested.

The estimate of the coefficient of soil linear expansion as a function of soil water content according to the approach of Braudeau and Donatelli (2001) is ongoing. Various utilities related to mapping data using the ESRI ArcView/ArcInfo format are also being developed.

## 2.4. Availability and feedback

*SOILPAR* is made available free of charge for non-commercial purposes. The installation package can be downloaded from: <http://www.isci.it/tools>. The user manual is provided with the software package and is available both on-line from the *SOILPAR* interface and as a stand-alone help.

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