

SWAT layer from SGDBE

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1 Introduction

Soil Water Assessment Tool (SWAT) is a comprehensive hydrological model working at the river basin scale. It was developed to quantify the impact of land management practices in large, complex watersheds (<http://swatmodel.tamu.edu/>). Among all the information required to run the model, parameters relative to the soil physical, chemical and mechanical properties are needed.

The Soil Geographical Database of Eurasia (SGDBE) provides a harmonised set of soil parameters covering Eurasia and Mediterranean countries at scale 1:1,000,000 (EC, 2003). It is part of the European Soil Database (ESDB), along with the Pedotransfer Rules Database (PTRDB), the Soil Profile analytical Database (SPADE) and the Database of Hydrological Properties of European Soils (HYPRES Wösten et al., 1999). Information in SGDBE is available at the Soil Typological Unit (STU) level, characterised by attributes specifying the nature and properties of soils. For mapping purposes, the STUs are grouped into Soil Mapping Units (SMU) since it is not possible to delineate each STU at the 1:1,000,000 scale (EC, 2003).

Thanks to the availability of ESDB, we propose to generate the SWAT.SOL input file for all SMUs. The soil properties are first gathered at the STU level and are then delivered at the SMU level, based on the dominant STU.

2 Generation of SWAT.SOL inputs

Information at the STU level is categorical. SWAT.SOL requires continuous input data. SWAT.SOL input data and their definition are given in Table 1. The estimation method of the SWAT.SOL input data at the STU level is summarised in Table 2. An extended description is given in the text.

The attributes needed at the soil layer level could either be retrieved from the estimated profile database or from the pedotransfer rules (PTR). The former gives a more detailed account of a representative profile for the STU, but it is not available for all STUs. The latter gives rough categorical estimations for the topsoil and the subsoil of each STU. In order to provide homogeneous data, only attributes derived from the STU properties or from PTR are used.

All data were processed in R (version 2.14.0). The main script (`esdb2swat.R`) and all the functions created to generate the SWAT inputs are distributed with this document.

2.1 SNAM

The soil name is set to the STU code when building the file. In the final product it is set to the SMU code.

2.2 HYDGRP

The Soil Hydrologic Group (HYDGRP) classes are defined according to the National Engineering Handbook (U.S. Department of Agriculture, 2007), on the basis of the depth class to an impermeable layer and the saturated hydraulic conductivity of the least transmissive layer. The former is directly available for each STU. The latter is obtained from the dominant texture class of the surface and subsurface layers using HYPRES class PTF (Wösten et al., 1999). A new rule is therefore established. When no information is available for one or two of the input variables, the least favourable class applicable to the other variable(s) is attributed. When no information at all is available, hydrologic group cannot be set. For non-soil STUs, HYDGRP is set to class D.

Table 1: Codes of SWAT.SOL input attributes, with their accepted range and their description. ($i \in [1, 10]$)

FIELD	RANGE	DEFINITION
SNAM		Soil name
HYDGRP	[A,B,C,D]	Soil Hydrologic Group
SOL_ZMX	[0,3500]	Maximum rooting depth of soil profile (mm).
ANION_EXCL	[0.01,1]	Fraction of porosity (void space) from which anions are excluded. [OPTIONAL] (default: 0.5)
SOL_CRK	[0,1]	Crack volume potential of soil (% soil volume). [OPTIONAL]
TEXTURE		Texture classes of soil layers. [OPTIONAL]
NLAYERS	[1,10]	Number of layers in the soil.
SOL_Z i	[0,3500]	Depth from soil surface to bottom of layer (mm).
SOL_BD i	[0.9,2.5]	Moist bulk density (g/cm ³).
SOL_AWC i	[0,1]	Available water capacity of the soil layer (mm water/mm soil).
SOL_K i	[0,2000]	Saturated hydraulic conductivity (mm/hr).
SOL_CBN i	[0.05,10]	Organic carbon content (% soil weight).
CLAY i	[0,100]	Clay (<0.002 mm) content (% soil weight).
SILT i	[0,100]	Silt (between 0.002 and 0.05 mm) content (% soil weight).
SAND i	[0,100]	Sand (between 0.05 and 2 mm) content (% soil weight).
ROCK i	[0,100]	Rock fragment (> 2 mm) content (% total weight).
SOL_ALB1	[0,0.25]	Moist soil albedo (only for surface layer ($i = 1$)).
USLE_K1	[0,0.65]	USLE equation soil erodibility (K) factor (only for surface layer ($i = 1$)).
SOL_EC i	[0,100]	Electrical conductivity (dS/mm). [Not currently active]

Table 2: Rules for attributing SWAT.SOL input values to STU's.

FIELD	R FILE	DESCRIPTION
SNAM		STU/SMU code
HYDGRP	hydrgrp.R	PTR based on topsoil and subsoil dominant texture classes and depth class of an impermeable layer.
SOL_ZMX	solzmx.R	Recode depth class of an obstacle to roots (ROO)
ANION_EXCL		Set to default value: 0.5
SOL_CRK		Set to default value: 0
TEXTURE		Layers texture codes
NLAYERS	solzmx.R	Default to 2.
SOL_Z i	solzmx.R	First layer set to 30 cm, second to SOL_ZMX
SOL_BD i		Obtained from HYPRES class PTF
SOL_AWC i		Obtained from HYPRES class PTF
SOL_K i		Obtained from HYPRES class PTF
SOL_CBN i	OC_sub.R	According to OC_TOP, set to 0, 1.5, 4 or 10 % weight. For subsoil, based on Hiederer (2009) .
CLAY i	av.text.R	Transform texture class (TEXTSRFDOM and TEXTSUBDOM) into clay, silt, sand contents.
SILT i	av.text.R	
SAND i	av.text.R	
ROCK i		According to PTR VS (volume of stone)
SOL_ALB1	albedo.R	Based on SWATxxx.mdb
USLE_K1		According to PTR ERODIBILITY and USDA-Agricultural Research Service (2006)
SOL_EC i		Set to default value: 0.

2.3 SOL_ZMX

The maximum rooting depth is obtained using STU attribute ROO, which gives the depth class of an obstacle to roots. Other attributes may restrict the depth: IL, presence of an impermeable layer, WR, waterlogging, AGLIM1, dominant limitation to agricultural use and DR, depth to rock, obtained with a PTR. All variables give depth classes. The average value of the interval defined for each class is used. SOL_ZMX is set to the most restrictive these conditions.

2.4 ANION_EXCL

The proportion of the soil porosity from which anions are excluded is set to the SWAT default value of 0.5. Litterature has to be investigated further to derive a PTR.

2.5 SOL_CRK

The potential volume of crack of the soil profile is set to SWAT default value of 0.5. Later versions could include the application of a PTR for clayey soils susceptible to swelling/shrinking, using the World Base Reference soil class to identify Vertisols (WRB-GRP VR) or mineralogy (type of clay) as an argument.

2.6 TEXTURE

This value is not processed, but it gives a summary of the layers texture. We used the same texture classes as in SGDBE (C: Coarse; M: Medium; MF: Medium Fine; F: Fine; VF: Very Fine; O: Organic; ?: No information), separated by a dash in cases where there are two layers.

2.7 NLAYERS

The number of layers defaults to 2, unless SOL_ZMX is less or equal to 30 cm.

The subsequent attributes must be set for each layer.

2.8 SOL_Zi

The depth of the first layer, SOL_Z1, defaults to 30 cm, unless SOL_ZMX is less than 30 cm. If present, the depth of the second layer, SOL_Z2, is equal to SOL_ZMX.

2.9 SOL_BD

The layer bulk density (BD) is obtained from the saturated water content applying

$$2.65(1 - \theta_s)$$

where 2.65 g.cm^{-3} is the density of the soil mineral and (θ_s) is the saturated water content resulting from HYPRES class PTFs with texture class and layer depth (topsoil/subsoil) as inputs.

2.10 SOL_CBN

The organic carbon (OC) content of the topsoil can be approximated using PTR21's result OC_TOP. The possible values Very low, Low, Medium and High are transformed into 0.1, 1.5, 4 and 10 % soil weight respectively. PTR 21 has been revised by [Jones et al. \(2005\)](#). In the revised version, there are 6 classes of OC_TOP, allowing to better estimate soil organic carbon content of organic soils. However the output of the revised PTR is only available as a raster file, because it uses CLC99 as land use input and applies temperature corrections on the mapped result of the PTR. The use of the revised PTR is possible but requires the generation of new SMUs.

We highlight here the issue of the handling of peat soils or organic layers in SWAT, since, according to SWAT example database, the model's maximum allowed value for organic carbon content is 10 % weight.

For the subsoil, estimations were made based on [Hiederer \(2009\)](#). For organic soils, OC content in the subsoil is set to 110 % of the value in the topsoil, regardless of the land use. For mineral soils, different coefficients are applied as a function of the land use. For arable lands, OC content of the subsoil is set to 70 % of the value of the topsoil, and for other land covers to 30 %.

2.11 SOL_CLAY, SOL_SILT and SOL_SAND

The texture fractions are evaluated from the dominant surface and subsurface textural classes. When these are unknown, PTR1 is used to estimate the dominant surface textural class. The value assigned for each class is the geometrical centre of the surface covered by the class in the textural triangle. For soil layers with no information or with no mineral texture, the sand, silt and clay contents are set to 0.

2.12 SOL_ROCK

The proportion of rock fragments is obtained from PTR412 giving the volume of stones (VS). The same value is used for both the surface and the subsurface layers.

2.13 AWC and SOL_K

The layer available water content, AWC, defined as $\theta_{FC} - \theta_{WP}$, with FC at pF 2.5 and WP at pF 4.2, and SOL_K, the layer saturated conductivity, are obtained from HYPRES class PTFs, with the texture class and the layer depth (topsoil/subsoil) as input.

2.14 SOL_ALB

The soil albedo is roughly estimated from the soil carbon content, with a PTF calibrated on the sample soil dataset provided with SWAT (tables `usersoil` in `SWAT2009.mdb`). The minimum albedo is set to 0.01 and the maximum to 0.23, for soil organic carbon content greater or equal to 1.45 % weight. Between these two extremes a simple linear regression is applied.

2.15 USLE_K

The erodibility factor of the USLE equation is estimated from PTR623, which gives classes of erodibility. Values are attributed to the classes according to the RUSLE reference guide ([USDA-Agricultural Research Service, 2006](#)).

3 Deliverable

Files are provided as inputs ready for SWAT2009. An ESRI grid, 1 km resolution, gives the soil mapping units (SMU) for Eurasia. A ESRI shapefile with the same information is also included. A dBase table gives SWAT.SOL required data. The table must be appended to the `usersoil` table in `SWATxxxx.mdb`. The `SNAM` field gives the SMU code and is used to link the table and the grid. The properties are those of the dominant STU. The representativeness of the dominant STU in the SMU is variable. Figure 1 shows a histogram of the percentage of the SMU area covered by the dominant STU. The frequency of SMU for which the dominant STU cannot be clearly identified are shown in a different colour.

Warning! The dBase file could not be imported to `SWAT2009.mdb` with Microsoft Access 2010. A csv file was created and used instead. However when imported and appended to `usersoil` table, some fields failed to produce the expected values. `SOL_AWC2` and `SOL_K2` were considered as integers while they are floats (and they are in the csv and appear as such if open with Excel). However when checking the Field Size in Design View, it is rightly set to Double and not Integer.

References

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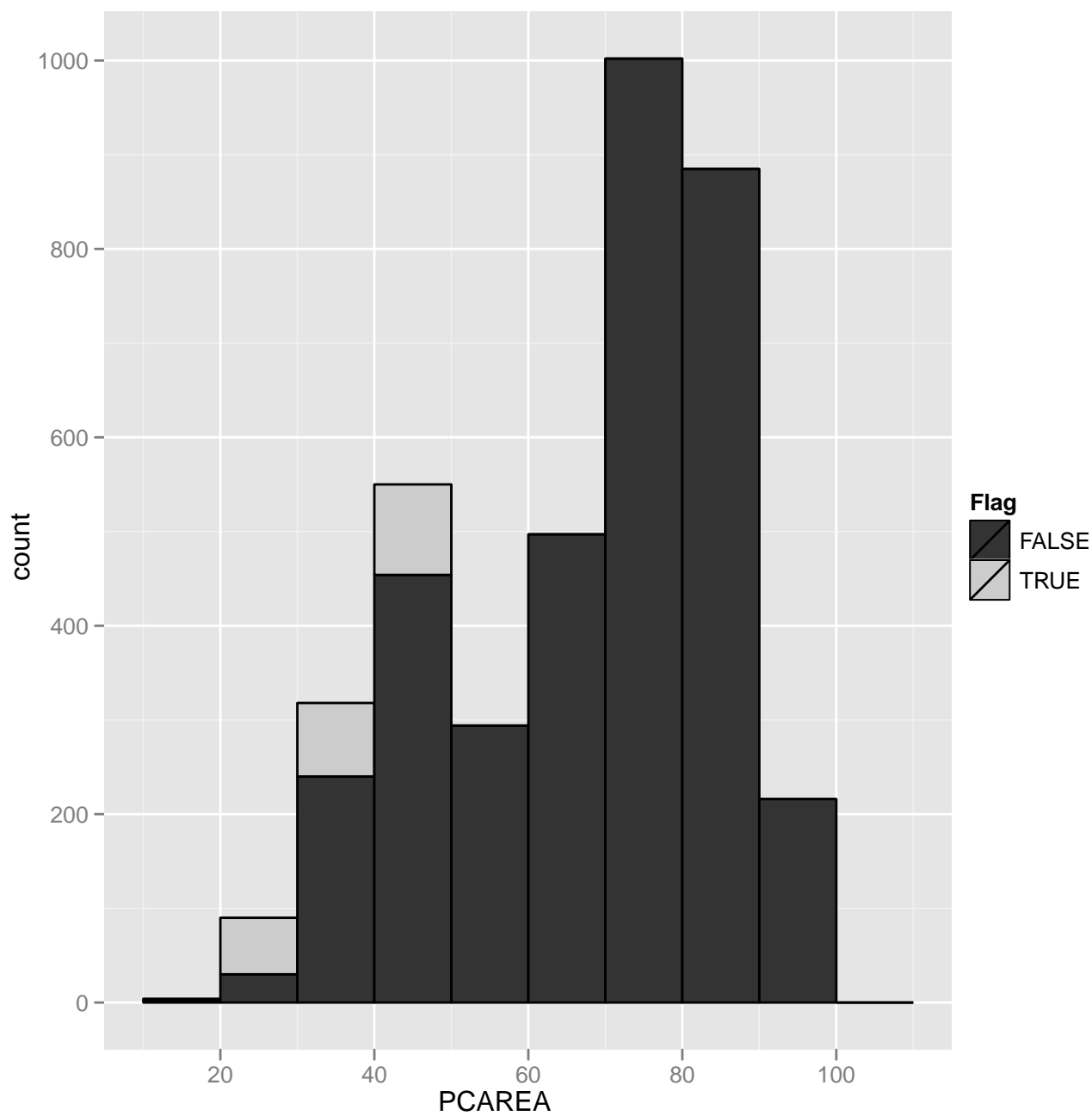


Figure 1: Frequency of percentage of SMU area covered by dominant STU. The flag indicates whether there are more than one STU covering the same proportion of the SMU area (TRUE) or there is only one (FALSE)

Wösten, J. H. M., Lilly, A., Nemes, A., Le Bas, C., Jul. 1999. Development and use of a database of hydraulic properties of european soils. *Geoderma* 90 (3-4), 169–185.
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