THE ADJUSTEMENT OF JRC PEDOTRANSFER RULES AT A SCALE OF 1:200,000

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Abstract: *The European Soil Bureau handles the European Soil Database, based on the 1:1,000,000 scale „Soil Geographical Map of Europe”. One of the four components of this database consists in a series of pedotransfer rules (PTR) allowing to derive a number of additional properties for practical purposes. These PTR are based on expert judgment, being mainly qualitative. Output attributes have been set up on the basis of the environmental parameters required for solving specific problems. The aim of this paper is the adjustment of the European Pedotransfer Rules at national level, on the basis of the 1:200,000 Soil Map. The data sources have been chosen as following: the soil map, the parental material map derived from the 1:1,000,000 soil map, the climatic data from MARS project, DEM, and the LCCS Map. For using the JRC Pedotransfer Rules, several macros have been developed. The outputs are saved as a .txt file, in order to join the main map (soil or LCCS) and to be spatial represented.*
The results could be used in models of soil water simulation, plant growth, or others soil processes, because there is a need of some new soil parameters, not existing on the soil map or in the databases. The structure of the macros developed for handling the PTR are presented in this paper, as well as some maps of new calculated parameters.

***Key words**: pedotransfer rules, soil map of Romania, soil parameters*

INTRODUCTION

Pedotransfer function (PTF) is a concept used in soil science literature, meaning predictive functions of certain soil parameters from other more available, easily, routinely, or cheaply measured parameters (BOUMA, 1989).

The first PTF was presented in a study of Lyman Briggs and McLane, in 1907 (quoted by BRIGGS and SHANTZ, 1912). They determined the wilting coefficient, which is defined as percentage water content of a soil when the plants growing in that soil are first reduced to a wilted condition from which they cannot recover in an approximately saturated atmosphere without the addition of water to the soil, as a function of particle-size.

The next step was the introduction of the concepts for field capacity (FC) and permanent wilting point (PWP) by Veihmeyer and Hendrickson, in 1927 (quoted by VEIHMEYER and HENDRICKSON, 1949). In the 1960s various papers dealt with the estimation of FC, PWP, and available water capacity (AWC) (SALTER and WILLIAMS, 1965). They explored relationships between texture classes and available water capacity, which are in fact class PTFs, or Pedotransfer Rules. They also developed functions relating the particle-size distribution to AWC, now known as continuous PTFs.

Afterwards, there was developed more comprehensive research using large databases. For soils from England and Wales, HALL et al. (1977) established FC, PWP, AWC, and air capacity (AC) as a function of textural class, as well as deriving continuous functions estimating these soil-water properties. In the USA, Gupta and Larson (1979) developed 12 functions relating particle-size distribution and organic matter content to water content at potentials ranging from -4 kPa to -1500 kPa. CLAPP and HORNBERGER (1978) derived average values for the parameters of a power-function water retention curve, sorptivity and saturated hydraulic conductivity for different texture classes, and Bloemen, in 1977 derived empirical equations relating parameters of the Brooks and Corey hydraulic model to particle-size distribution (MINASNY and MCBRATNEY, 2002).

Lamp and Kneib introduced in 1981 the term *pedofunction* (LAMP and AMESKAMP, 1998), while BOUMA and VAN LANEN (1986) used the term *transfer function*. To avoid confusion with the term transfer function used in soil physics and in many other disciplines, Johan BOUMA (1989) later called it *pedotransfer function*.

Since then, the development of PTFs has become an important research topic in the area of soil science and environmental research, all over the world. Most current PTF research focuses only on the development of new functions for predicting soil physical and chemical properties for different geographical areas or soil types, while there are also efforts to collate and use the available PTFs (MCBRATNEY et al, 2002).

At the European level, the Joint Research Centre (JRC), founded as a service of the European Commission, provides scientific and technical support for the conception, development, implementation, and monitoring of EU policies, including those regarding soil. The European Soil Bureau Network (ESBN), located at JRC, was created in 1996 as a network of national soil science institutions. Its main tasks are to collect, harmonise, organise and distribute soil information for Europe (http://eusoils.jrc.ec.europa.eu). In order to achieve these goals, JRC developed the European Soil Information System, a main database regarding the soil cover of the entire continent, with four components as follows:

- the Soil Geographical Database of Europe (based on the 1:1,000,000 scale soil map of Europe),
- the Georeferenced Soil Database for Europe at scale 1:250,000, in fact a soil inventory at this scale (DUDAL et al., 1993),
- Soil Profile Analytical Database, called SPADE 1, and containing soil profile characterisations with physical and chemical analyses (MADSEN and JONES, 1995),
- Pedotransfer Rules Database.

The fourth component of the European Soil Database is a series of pedotransfer rules (PTR) allowing to derive a number of additional properties for practical purposes. These are based on expert judgement, mainly qualitative, and assume that a weight is given to the confidence level of individual inferred attributes.

Output attributes have been set up on the basis of the environmental parameters required for solving specific problems, e.g., hydrology of soil types for predicting catchment response to rainfall and standard percentage of runoff; location and sensitivity of wetlands; soil buffering capacity for predicting soil susceptibility; vulnerability of ground and surface water to pollution by agrochemicals and farm waste; soil erosion potential, etc. (http://eusoils.jrc.ec.europa.eu/esbn/Pedotransfer.html).

The output attributes are class values due to the low level of precision of some input attributes. The thresholds selected for class intervals were chosen as a compromise between currently established values used in Soil Science, and the level of precision at the scale of input data (in this case 1:1,000,000). As a result, the adopted values may not always correspond to the thresholds necessary for environmental problems.

The aim of this paper is to present an attempt to adjust these pedotransfer rules, developed at the scale 1:1,000,000 at another scale.

MATERIAL AND METHODS

The JRC Pedotransfer Rules Database handles 41 pedotransfer rules (PTR), with an addition of other 8 PTRs, developed in the MARS program framework. A PTR looks like a table with several columns as input parameters and two or three columns as output parameters. The last two columns hold information about the author of the PTR and the updating time. Each row of the table is an "instant" of the PTR, a specific condition for that PTR. The input or output variables are described by a set of string or numeric values, interpreted in the database dictionary. For example, in fig. 1, an extract of the first PTR is shown.

No.	SN1	SN2	SN3	TXT1	TXT2	PM11	PM12	PM13	TXT	TXT.CL	Auth.	UPDATE
1	*	*	*	1	*	*	*	*	1	h	CL	11.07.2000
2	*	*	*	2	*	*	*	*	2	h	CL	11.07.2000
3	*	*	*	3	*	*	*	*	3	h	CL	11.07.2000
4	*	*	*	4	*	*	*	*	4	h	CL	11.07.2000
5	*	*	*	5	*	*	*	*	5	h	CL	11.07.2000
6	*	*	*	9	*	*	*	*	6	h	CL	03.07.2000
7				0	0				0	h	CL	29.09.2000
8	B			0	*	1	1	0	2	l	JJL	22.09.2000
9	B	d		0	*	7	3	9	1	l	JJL	22.09.2000

SN1 – SN3: First, second, and third character in item SOIL;
TXT1, TXT2: Dominant and secondary surface textural class;
PM11 – PM13: First, second, and third character in item MAT1 (Dominant Parent Material);
TXT: Dominant surface textural class, completed from dominant STU (Soil Typological Unit).
CL: Confidence level of the corresponding Pedotransfer Rule infered item
*: Any value of the variable

Figure 1. An extract of the first Pedotransfer Rule – the soil textural class

The main data used in this analysis, taking into consideration the various input types, are as follows: a) the soil map of Romania, 1:200,000 scale, version 1 (1995), together with a correspondence table relating the specific Romanian soil types and the FAO 74 legend; b) the LCCS (Land Cover Classification System) map, at the scale 1:100,000; c) the soil parent material map at the scale 1:1,000,000, from FAO1MIL; d) the Digital Terrain Model SRTM-30, obtained by a resampling process from the 90 m resolution SRTM (BALTEANU et al., 2010), used to compute the average slope and aspect for a soil polygon; e) the climatic data provided by the European project ATEAM, on a grid 10 x 10 km, assessed for the centre of the soil polygon, and f) the JRC Pedotransfer Rules Database.

The steps followed to achieve the goal of adjusting the JRC PTRs are as follows (see the flowchart of the applied procedure in fig. 2):

- Identifying the input data sources (maps, databases, expert information);
- Gathering and preparing input data from sources (by reading data, overlaying different layers, averaging data on each polygon of a layer, using expert evaluations);
- Developing specific software (a set of macros) in VBA environment;
- Running the specific software;
- Exporting the outputs as .txt files;
- Joining the existing maps with the new .txt files in order to obtain new maps.

The main issue was to identify the input data sources, and to adjust some of the existing data to the scale that was used in the study. There are 47 input data, many of them being parts of another input data (for example, each character of item Soil Type, each character in item PM1 – Dominant Parent Material, etc.). On the other hand, some output data from a certain PTR become inputs for other PTRs. For the soil parent material (PM), the FAO1MIL map has been used. By overlaying it with the soil layer, a full description of PM types (including the area percentage of them) for soil polygons was obtained. The main PM type for each polygon was considered as the Dominant Parent Material (PM1), while the second one was assumed to be the secondary PM (PM2). For using the climatic data, the ATEAM data has been computed for the polygon centroid. The topographical parameters (elevation and slope) have been averaged for soil polygons using Spatial Analyst from ArcView.

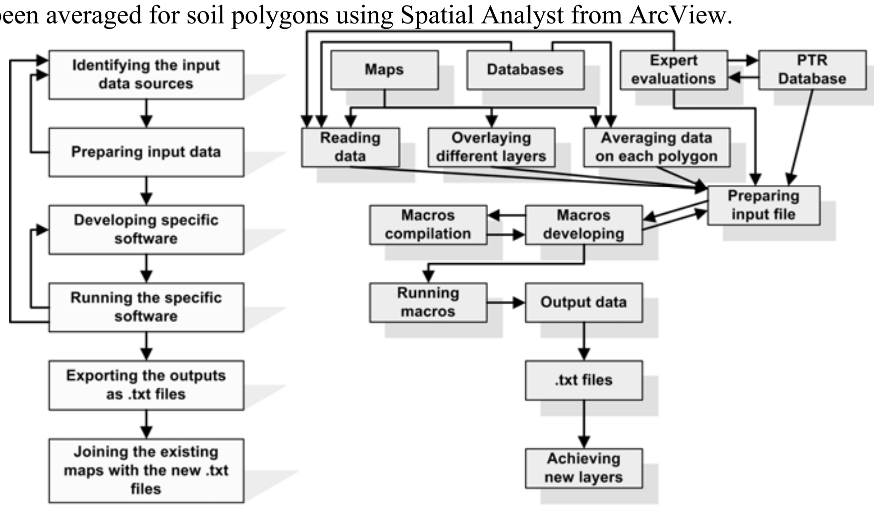

Figure 2. The flowchart of adjusting the JRC Pedotransfer Rules to the scale of 1:200,000

RESULTS AND DISCUSSIONS

The first step for PTR adjusting was to identify the input data sources. Several experts rules have been developed in order to obtain the needed input parameters from the soil map at 1:200,000 scale, which has no such more information on soil as the European Soil Map at the scale of 1:1,000,000. The information about PM1 and PM2 have been obtained through overlaying procedure, as it was described previously. The Soil Map has been overlaid with the LCCS map, the outcome layer being used as input data in several PTRs. On the other hand, the climatic parameters have been computed for each LCSS & Soil polygon.

For each PTR, a macro has been developed, with several specific subroutines, as shown in fig. 3.

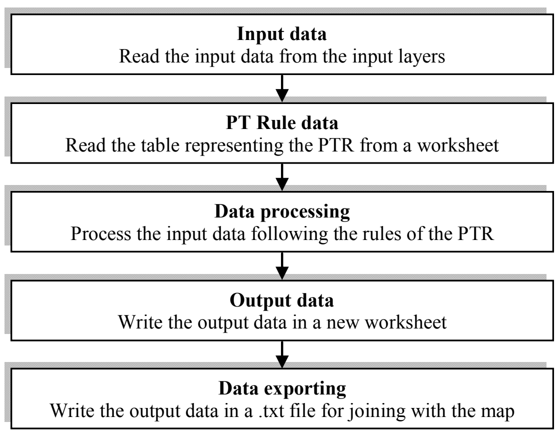

Figure 3. The main structure of a PTR macro.

After running the specific macro, the outputs was saved as a .txt file and joined with the soil coverage. The results could then be viewed by drawing a new map. In fig 4, the results of the first two PTRs are shown.

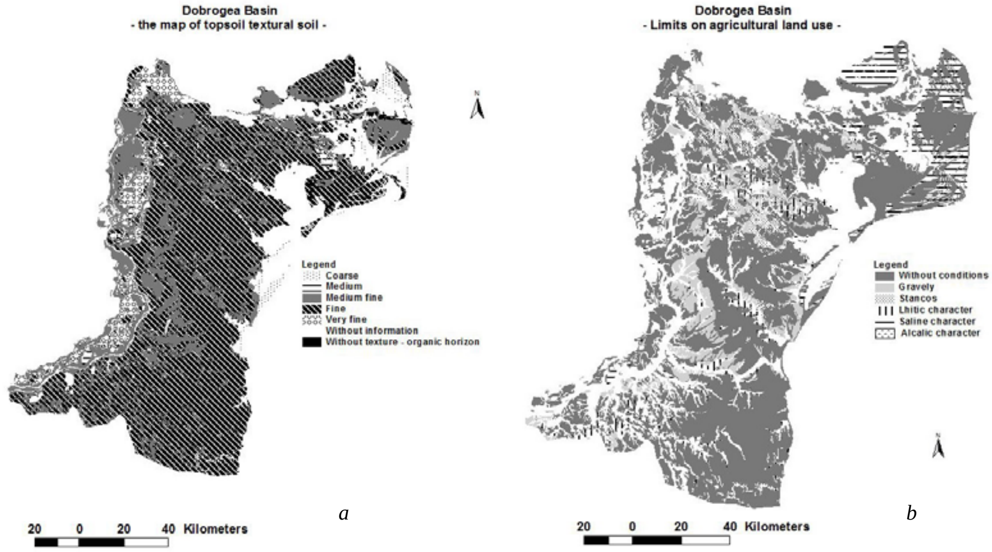

Fig. 4. The first two JRC pedotransfer rules: a) Topsoil textural class, b) Limits on agricultural use.

In February 2010, a new version of Digital Soil Map of Romania has been prepared by the Soil Information Department of ICPA. The layer has been corrected taking into account a new hydrological layer based on orthophotos. Therefore, the macros and procedures developed in this paper have to be applied on this new version. The macros are still available, but the information prepared by overlaying different layers has to be computed once again.

CONCLUSIONS

The JRC Pedotransfer Rules PTR, developed for a scale of 1,000,000, have been adjusted for Romania at a different scale (1:200,000). To achieve this goal, some specific macros have been developed, which could be also used to adjust other pedotransfer functions.

Several expert rules have been used in order to obtain new information from the existing 1:200,000 soil map.

New information has been obtained also by overlaying different layers, like soil map and Parent Material map, or the soil map and LCCS map. By running the specific macros developed in this paper, several new parameters have been obtained and new maps are drawn.

In February 2010, the second version of Digital Soil Map of Romania was released, therefore, the macros and procedures developed have to be applied on this new version.

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