Renewal of the Hungarian Soil Spatial Data Infrastructure by goal oriented digital soil mapping

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Abstract

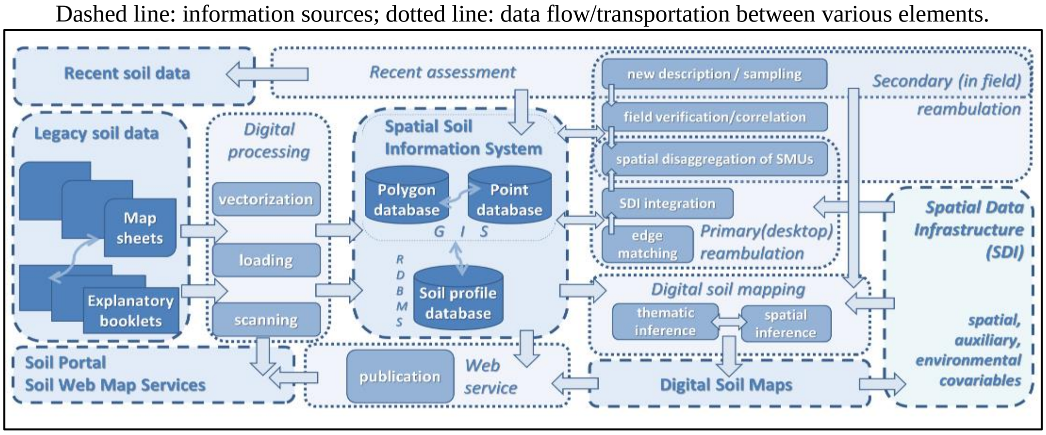
The DOSoReMI.hu (Digital, Optimized, Soil Related Maps and Information in Hungary) project was started intentionally for the renewal of the national soil spatial infrastructure in Hungary. During our activities we have significantly extended the potential, how spatial soil information requirements could be satisfied. Soil property, soil type as well as functional soil maps were compiled. The set of the applied digital soil mapping techniques has been gradually broadened incorporating and eventually integrating geostatistical, machine learning and GIS tools. Soil property maps have been compiled partly according to GlobalSoilMap.net specifications, partly by slightly or more strictly changing some of their predefined parameters according to the specific demands on the final products. The web publishing of the results was also elaborated creating a proper WMS environment.

Keywords: digital soil mapping, spatial soil information, spatial soil data infrastructure

1 Introduction

The goal of soil mapping is the spatialization of various thematic knowledge related to soil cover. Soil maps are thematic maps, where theme is determined by some specific information related to soils. This can be a primary or secondary (derived) soil property or class as well as any knowledge characterizing functions, processes or services of soils. The greatest and inevitable challenge of the compilation of soil maps is the regionalization of the local knowledge, its spatial inference (Miller & Schaetzl, 2014). From a certain point of view, the development of soil mapping (Brevik et al., 2016) is the conscious expansion of the repository of these methods. (i) mental space usage, (ii) delimitation based on soil-landscape models, (iii) various interpolation methods, (iv) introduction of ancillary, environmental, spatial data as auxiliary co-variables related to various components of soil forming processes. Essentially, this latter is the base of digital soil mapping.

Figure 1: Framework of spatial soil information services.
Dashed line: information sources; dotted line: data flow/transportation between various elements.



Mapping is inherently predictive, the value or class of a mapped variable can only be estimated at unvisited locations (Gessler et al. 1995; Scull et al. 2005). Spatial soil information can be characterized by three basic aspects which are more or less inter-related: thematic, geometrical and uncertainty issues. Any change in these issues theoretically would induce the compilation of a new map with the required parameters. In traditional soil mapping the creation of a new map was troublesome and laborious. As a consequence robust maps were elaborated and rather the demands were fitted to the available map products.

Since the opportunity of a recent, extended, soil surveys is extremely low, the data of previous surveys should be exploited thoroughly for the elaboration of target specific, goal oriented spatial soil information applying up-to-date methods of digital soil mapping (DSM). The framework of DSM (Hartemink et al., 2008; Lagacherie & McBratney, 2007; McBratney et al., 2003) involves spatial inference of the information collected at sampled points based on ancillary environmental variables related to soil forming processes. Due to the simultaneous richness of spatial inference methods and the potentially available auxiliary environmental information (Grunwald, 2009; Hengl, 2009; Mulder et al., 2011), there is a high versatility of possible approaches for the compilation of a given soil (related) map. The activity of DSM goes beyond mapping purely primary and secondary soil properties, the regionalization of further levels of soil related features (processes, functions and services) is also targeted (Minasny et al., 2012).

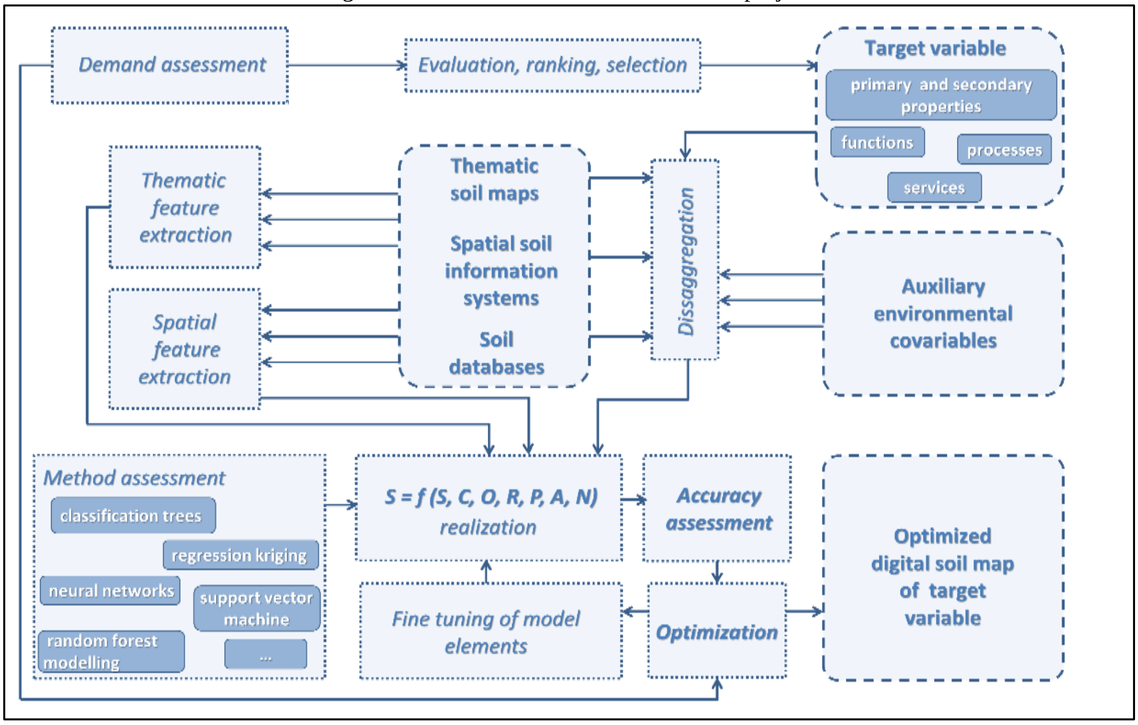
Grace to former soil surveys and mapping activities significant amount of soil information has accumulated in Hungary (Fig.1). Present soil data requirements increasingly demand advanced or new kinds of spatial soil information, which cannot be fully satisfied by legacy soil maps or formerly elaborated databases. Due to the more and more frequently emerging discrepancies between the available and the expected data, there might be notable imperfection as for the accuracy and reliability of the delivered products. Several national programs have emerged recently, whose successful completion necessitates the application of suitable data, which need to be spatially exhaustive and consistent as well as both globally and locally reliable. Also, accurate soil information is needed not only for primary soil properties, but dominantly for specific basic and or higher level soil features, which formerly had not even been mapped. Due to these challenges, the Hungarian spatial soil data infrastructure is significantly changing. The DOSoReMI.hu (Digital, Optimized, Soil Related Maps and Information in Hungary) project aims to significantly extend the potential how soil information requirements could be satisfied in Hungary.

2 Materials and methods

Digital soil mapping is essentially based on spatial modelling of the complex relationship between a specific soil variable and its affecting/determining/indicating factors. For the compilation of a specific map proper (i) reference soil data, (ii) ancillary information and (iii) spatial inference method is required to model the relations between the predicted and the explanatory environmental variables.

Reference information on target variables comes from three main, survey originated, legacy data sources: Hungarian Soil Information and Monitoring System (Várallyay, 2002); Hungarian Detailed Soil Hydrophysical Database (MARTHA, Makó et al., 2010); Digital Kreybig Soil Information System (DKSIS; Pásztor et al., 2010).

Figure 2: Framework of the DOSoReMi.hu project.



For the mapping of soil properties, relevant auxiliary environmental variables were used. The variables, in one hand, were selected to characterize the soil forming factors, which determine the predicted soil properties. On the other hand, multitemporal and multispectral remotely sensed images were used, which provide direct information on the surface and certain indirect information on subsurface conditions ruled by soil features.

Spatial inference of reference data has been carried out using a variety of geostatistical and data mining tools: co-kriging with external drift, regression kriging, sequential stochastic simulation, classification and regression trees, random forests, quantile regression forests, support vector machines. In addition to provide "pure" spatial prediction, the uncertainty of prediction has been also modelled by detailed accuracy assessment. Both global and local uncertainty have been targeted.

The predictand soil properties are selected on thorough demand assessment and then are multi-mapped by the aid of selected sets (i) of reference data, (ii) spatial auxiliary information and (iii) inference methods. Optimized products are achieved by iteration, which is based on the results of accuracy assessment supplemented with the evaluation of the implemented resources (Fig. 2).

3 Results and discussion

The main result of the goal oriented digital soil mapping carried out in the frame of DOSoReMI.hu is a collection of spatial soil information in the form of unique digital soil map products (in a more general meaning), which were optimally elaborated for the regionalization of specific soil (related) features. Significant part of them were never mapped before, even nationally with high (~1 ha) spatial resolution. Based upon the collected experiences, the full range of GlobalSoilMap.net (GSM; http://www.globalsoilmap.net/) products, is also targeted (Fig. 3). The maps elaborated according to GSM specifications represent the Hungarian contribution to the GlobalSoilMap.net project (Minasny & McBratney, 2010). Further GSM.net conform map products are also under development in the frame of DOSoReMI.hu to contribute to the worldwide activities.

Based on more extended data infrastructure, it is suggested that national initiatives could produce more accurate and reliable products. It is hoped to achieve further progress in the performance by expanding the pool of environmental co-variables applied and by testing additional methods (cubist, neural networks, etc.).

The assessment of local uncertainty of the prediction makes the application of an inset map possible for the expression of the inherent vagueness of spatial prediction in the layout of the compiled spatial soil information for the visualization of the reliability of the deduced prediction (Fig. 4). In addition to local, global accuracy certain measures of the results are also communicated. The cartographed map products also display metadata related to the set of reference data, predictors and the applied method. We propose their general usage for displaying the results of digital maps elaborated using geo-mathematical methods and/or environmental models.

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Figure 3: Overview and status of the maps targeted by the DOSoReMi.hu project

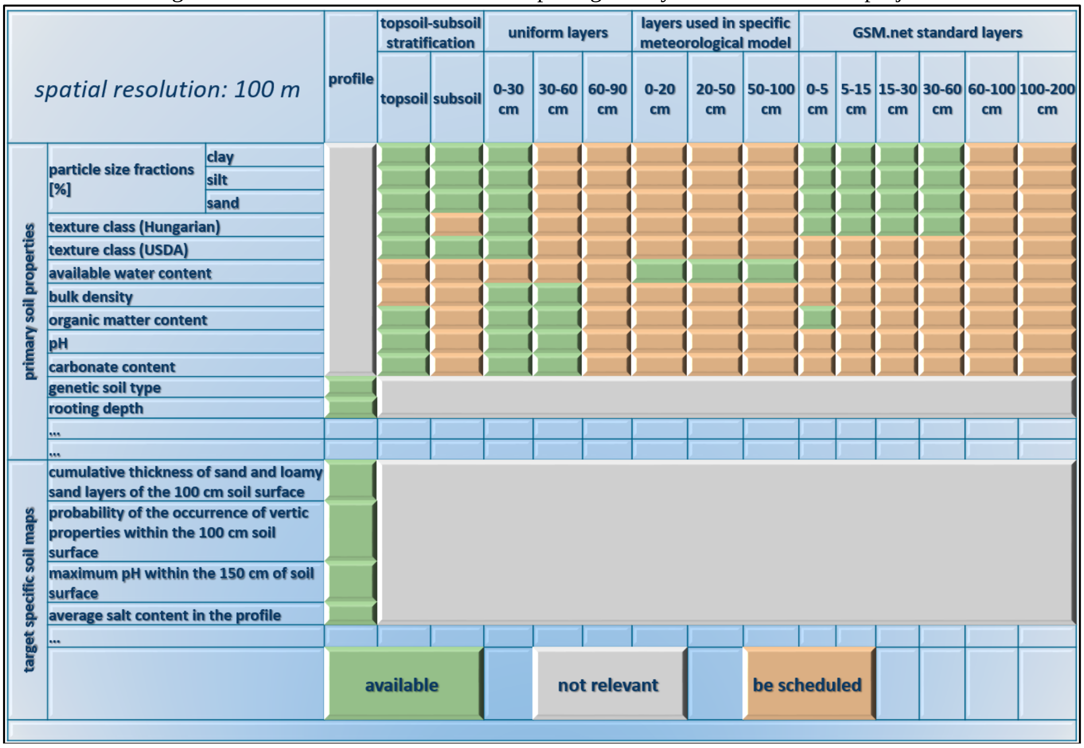
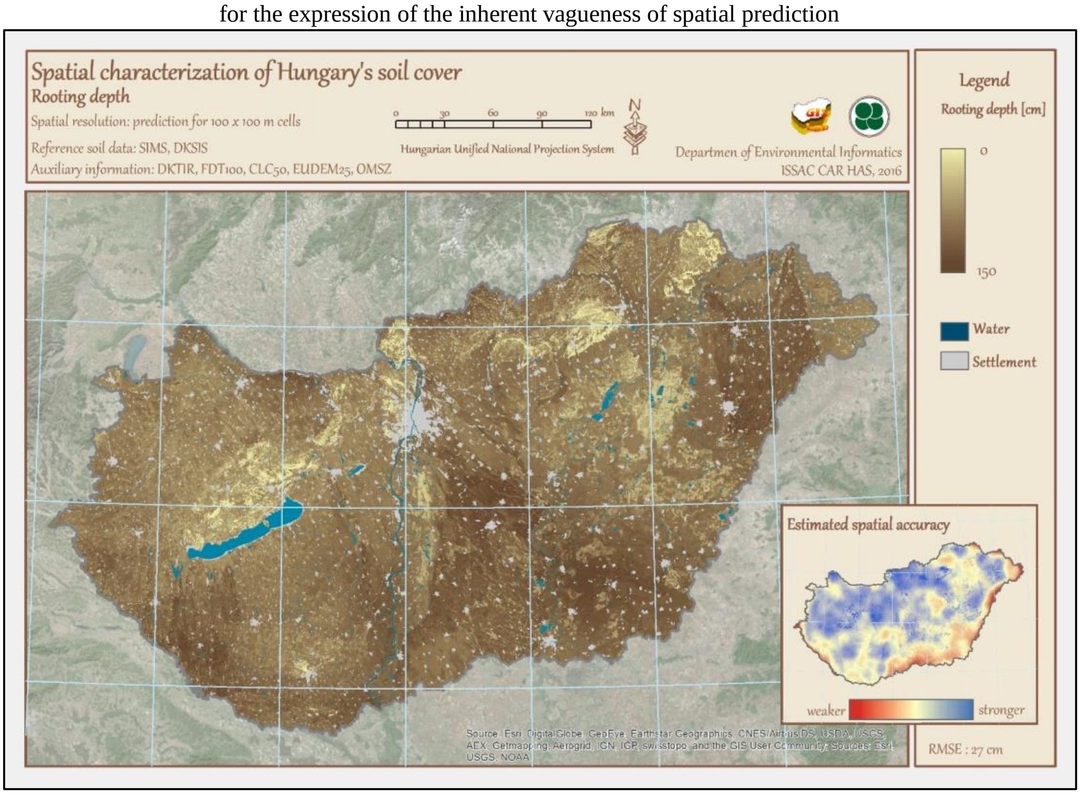


Figure 4: Layout of novel, digital soil property map supplemented with metadata on its compilation as well as an inset map for the expression of the inherent vagueness of spatial prediction



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