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GENERATION OF NEW SOIL INFORMATION BY COMBINATION OF DATA SOURCES OF DIFFERENT CONTENT AND SCALE USING GIS AND BELIEF STRUCTURES

Introduction

Todays soil maps are the result of many decades of field work supported by laboratory measurements and different cartographic methods. They are edited at various scales and contain a variety of attributes. Future attempts to update these maps with regard to attributes and/or scale will most probably be accomplished by interpretation of other spatial soil data as well as non-soil data sources. The results of the interpretation process will then be integrated into existing soil maps. Field work is not to be expected in larger extent because of decreasing financial resources available for such work (7).

As computers and Geographical Information Systems (GIS) become more common in map analysis and spatial data processing, there is a strong need to make explicit and transparent the process of data interpretation and the integration of the results into existing maps. Otherwise, purely because of the size of files used and the complexity of many computer algorithms for data processing, both the expert and the final user will have difficulties to keep track of the single steps in data analysis, interpretation and elaboration of final map. This may turn the perception of the whole GIS-supported process of map update into a `black box` procedure, and by this may heavily affect the final acceptance of the maps (3). This is especially important, as many data sources are influenced by different sources and degrees of uncertainty (14).

Knowledge processing and treatment of data uncertainty with computers offer different possibilities to represent information, e.g. probability models (17), possibility models and their processing with fuzzy-rules (8, 9), belief structures (15), and others (17). Common to most of these methods is their ability to express quantitatively the strength of a `fact` in a certain interpretational context, and sometimes as well to include partial knowledge or enable the user to represent ignorance as a factor in mapping process .

This paper reports results of a study to represent spatial knowledge about soil with *belief* structures. The study area is situated approximately 50 km south of Berlin (Germany) in a sand-loess region at the southern border of the state Brandenburg.

Very fertile soils on loess material can be found next to very low productivity soils, which developed on fluvial sand, which normally underlies the loess, but may occur at the surface because of erosion. Existing soil map data and other data sources are translated into *belief* structures. Update of these structures is performed using the *Transferable Belief Model* (TBM); (15). It is demonstrated, how very generalized soil information at a small scale (1 : 300.000) can be combined with large-scale information from agricultural soil quality maps (ca. 1 : 5.000) and actual, dGPS-georeferenced measurements of apparent soil electrical conductivity (EC_a). The final output is a map of soil types and forms at a large scale with a supplemental map of conflicts from the data combination process. The paper is a continuation of earlier studies about possible applications of the TBM in soil science (6).

Materials and Methods

Two spatial and two non-spatial data sources were available for a 46 ha agricultural field in the study area. Spatial data sources are the agricultural soil quality map at a scale of approximately 1 : 5000 (*Bodenschätzung, BS*), and measurements of the apparent electrical conductivity (EC_a) at a spatial interval of 24 m, georeferenced with a dGPS device and subsequently interpolated on a 5 m grid using kriging. Non-spatial data sources are the general soil survey map of Brandenburg at a scale of 1 : 300 000 (*Bodenübersichtskarte, BÜK300*), and published information about typical soil types in the study area (4, 10, 12).

The *BÜK300* map was edited at the end of the 20th century and renders polygons of soil form associations. A soil form is a specific combination of parent material and soil type according to the German soil classification (2). The legend contains denominations of associated soil forms and an assessment of the spatial dominance of the respective soil forms in the legend category. The study field is located in one single polygon of the *BÜK300*, and therefore this data source can be treated as non-spatial information, because only the information from the legend entry is used. The *BS* map was edited in the 1930s and contains soil polygons with information about parent material, integrated soil texture to a depth of 100 cm, and the soil development stage (2). EC_a measurements were performed in spring 2000 at field water capacity, using the EM38 sensor in vertical mode. EC_a of soil material is mostly influenced by soil clay and water content, as well as to a minor extent by organic matter, soil density, and other factors (McNeil 1980).

Representation of soil data at a certain location with belief structures within the TBM (15) results in two levels of information: (1) a hypothesis about the soil form (or several soil forms), and (2) a *mass of belief* (*mob*) with regard to this hypothesis. The *mob* is on a scale between 0 and 1. The TBM allows for different hypotheses (or sets) and *mob* for a certain location. Partial or total ignorance about the soil is represented by the empty set $\{\emptyset\}$ and its respective *mob*. Update of beliefs is accomplished using *Dempster*'s rule of combination (16). From the *mob* assigned to the empty set by the belief update procedure, a weight of conflict (*woc*) can be derived (*woc* = - log (1-*mob*{*Ø*})).

Table 1

Example of representation of knowledge about soils with belief structures and update of beliefs to introduce new data (G - "good soil"/B - "bad soil"); (see text for details)

(1) initial *belief* structures		*mob* (intial situation)		*mob* (after reliability correction)		
data source	reliability	{*G*}	{*B*}	{*G*}	{*B*}	{G, B}
"old soil map"	0.70	**1.00**	0.00	**0.70**	0.00	0.30
"yield map"	0.80	0.00	**1.00**	0.00	**0.80**	0.20
(2) *belief* update		"yield map"				
	mob/hyp.	0.80 {*B*}	0.20 {*G, B*}			
"old soil map"	0.70 {*G*}	0.56 {*Ø*}	0.14 {*G*}			
	0.30 {*G, B*}	0.24 {*B*}	0.06 {G, B}			
(3) final *belief* structures						
hypotheses	{G}	{B}	{G, B}	{*Ø*}	*woc*	
mob initial	0.14	0.24	0.06	**0.56**		
mob normalized	0.32	**0.55**	0.13	0.00	**0.36**	

Source: Author's own data.

Table 1 presents an illustrative example for representation of soil knowledge, and the update procedure, when new knowledge is available. In this example, two basic hypotheses are possible: „good soil" {*G*}, and „bad soil" {*B*}. Additional, two more sets are possible: both alternatives {*G, B*} and ignorance, represented by the empty set {*Ø*}. The first data source is information from an old soil map, which shows {*G*} for this location. However, the second data source, a more recently created and reliable dGPS yield map, shows very low yields at the location, and therefore is interpreted as {*B*}. Both data sources are weighted according to their assumed reliability, and combined. After combination and normalisation of all *mob* (to sum to 1), the *mob* supporting hypothesis {*B*} is higher than for {G}. Because of this, the resulting, updated map would display „bad soil" for this location. However, the *woc* is rather high, and should be taken into consideration, when using the soil map to derive decisions for e.g. land use planning or production systems. For example, before taking a decision more research could be dedicated to this location first, to be more sure about the real quality of the soil, and effectivly reduce ignorance or unreliable data.

The available spatial and non-spatial data sources for the study area were translated into soil forms. By this, every data source (non-spatial sources) or the respective categories of the maps (spatial data sources) result in a certain hypothesis or set of hypotheses with a weighting factor (table 2). Applying the weighting factor results in the respective *mob* values for each hypothesis. While only one legend category of *BÜK300* appeared on the study field, the mentioned soil forms with there respective spatial dominance were used for every location. The resulting map contains four different hypotheses and respective *mob* values to represent the belief, that at a certain

Table 2

Interpretation of different data sources with regard to soil forms for the study area

data source	weight[b]	Soil form[a]						
		YK$_1$	LF$_2$	LF-BB$_2$	LF$_3$	LF-BB$_3$	lBB$_4$	LF-BB$_5$
		u/sö	sö/s		sö/ls		s/s	s/ls
BÜK300								
LF/LF-BB	0.61	-	1.00	1.00	-	-	-	-
LF/LF-BB	0.18	-	-	-	1.00	1.00	-	-
lBB	0.18	-	-	-	-	-	1.00	-
LF-BB	0.03	-	-	-	-	-	-	1.00
literature								
YK	0.03	1.00	-	-	-	-	-	-
BS								
Sl 5	var.	-	-	-	-	-	1.00	-
Sl 4	var.	-	-	-	-	-	1.00	1.00
Sl 3 LöD	var.	-	-	-	-	-	-	1.00
lS 4 LöD	var.	-	-	1.00	-	1.00	-	1.00
SL 4 LöD	var.	-	1.00	-	1.00	-	-	-
EC$_a$ (1)[c]								
< 18	var.	-	-	-	-	-	1.00	-
18-22	var.	-	-	-	-	-	-	1.00
20-24	var.	-	-	1.00	-	-	-	1.00
24-28	var.	1.00	1.00	1.00	1.00	1.00	-	-
>28	var.	1.00	1.00	-	1.00	-	-	-
EC$_a$ (2)[c]								
< 18	var.	-	-	-	-	-	1.00	-
18-22	var.	1.00	-	-	-	-	-	1.00
20-24	var.	-	-	1.00	-	-	-	1.00
24-28	var.	-	1.00	1.00	1.00	1.00	-	-
>28	var.	-	1.00	-	1.00	-	-	-

[a] abbreviations according to German classification (KA5): 1st row 'soil types': YK – *Kolluvium*, LF – *Fahlerde*, LF-BB – *Fahlerde-Braunerde*, lBB – *Braunerde (lessiviert)*; 2nd row 'parent material' (the slash '/' separates layers): u – silt, sö – sand loess, s – sand, ls – loamy sand;
the respective WRB soil types would be: *Kolluvium – Kolluvisol*, *Fahlerde – Haplic Luvisols*, *Braunerde – Endoeutric Albeluvisols*;

[b] weights are derived from information with regard to spatial dominance for spatially uniform data sources *BÜK300* and *literature*; weights are spatially variable for the other data sources because of fuzzified border regions between different data levels;

[c] values are given in $mS*m^{-1}$, corrected for standard soil temperature of 25 degrees Celsius;

Sources: Arbeitgruppe… (2), Dobers E. S. (4), Maudrei F. (12).

location the respective soil form can be expected: *mob*({LF_2, LF-BB_2}) = 0.61, *mob*({LF_3, LF-BB_3}) = 0.18, *mob*({lBB_4}) = 0.18, *mob*({LF-BB_5}) = 0.03. Because the *BÜK300* legend category does not mention the colluvial soil form (YK), no *belief* is created for this hypothesis at this point (table 2, *BÜK300*).

Review of literature and own field work in the surrounding study area made necessary to introduce another soil form: colluvial soils on accumulated silt over sand loess material (YK_1). As they only appeared rarely, a respective weight was applied to account for this (table 2, literature).

The *BS* map was translated using expert knowledge and own field experience gained in the region over several years. As well, the *BS* soil map did not show any polygon with a category, that could be interpreted as YK_1 for the study field. Weigthings were produced by scale-dependent fuzzyfication of the polygons on the study field. Therefore weightings vary for the categories with respect to the distance from the polygon border (table 2, BS).

Interpolated EC_a data were interpreted semi-quantitatively to account for layering of parent material, and by this assigned to the different soil forms. As well, own field experience was included to find categories of EC_a values. As EC_a-measurements showed unexpected small values on colluvial soils, a second interpretation scheme was designed. The first scheme EC_a (1) takes into account the assumed relation between EC_a values and parent materials, which would be expected from theoretical considerations alone. The second scheme EC_a (2) includes the specific local knowledge, that colluvial soils show unexpected small values. The small EC_a values are inconsistent with the underlying theory of influencing factors on EC_a (13), but could be reproduced by repeated measurements and other scientists in the study area (11). As with *BS*, weigthings result from fuzzyfication of EC_a values and vary within the field (table 2, ECa (1), ECa (2)).

All data sources were processed using Idrisi GIS software (1). Vector data were transformed into raster layers of 5 m cell resolution. Data layers were combined using the TBM. Computations were performed with specifically written software. Results were reimported into GIS for final analysis. The *woc* value was transformed into five categories to ease interpretation.

Results and Discussion

The first step of representing the information from the *BÜK300* map with belief structures does not give any spatial differentiation for the study field because the field is situated completely within one *BÜK300* polygon. As well, integration of the information from literature studies only extended the set of hypotheses for each raster cell of the study field, but did not introduce any spatial differentiation. The respective *mob* values for the hypotheses were only slightly changed. The updated map could be named an `extended *BÜK300* map`.

Integration of the the *BS* map information produced the first spatial structures (fig. 1, left). Display of the hypothesis with the highest *mob* reproduces the spatial structures, that are present on the *BS* map with regard to its polygon borders. This is expected, as the only spatially differentiating factor in the belief update process so far is the *BS* map. The shades for the black/white map legend are designed in such a way, that dark shades dominate whenever the first, second, or third parent material is included into the legend category. This is done, because the soil types associated with this parent material tend to be more fertile.

The supplementing *woc* map shows, that a few areas on the field now fall into a category where priority would be rated *low* to *medium* for directing map review, e.g acquisition of new data sources or field work (fig. 1, right). The *BS* map contains a few polygons, which are believed to contain lBB_4 or $\mathrm{LF\text{-}BB}_5$ soil forms. The *mob* values for these soil forms are at maximum on the *BS* map, and therefore a general conflict with the *BÜK300* map information has to turn up (see table 1 for the general principle of update with the TBM). On the uniform *BÜK300* map these soil forms have a very small *mob* only because of their minor spatial dominance. However, the *BS* map is displaying information at a much larger scale, so these *woc* are interpreted as conflicts of scale here. The *mob* values of the updated map are normalized to sum to 1 before integrating the interpretation of EC_a data in the next step.

Integrating the beliefs about soil forms derived from EC_a data using the first interpretation scheme results in a much more differentiated spatial distribution of soil forms on the field (fig. 2, left). The supplementing *woc* map indicates several regions which need map review (fig. 2, right): 14% of the area is rated *high* with regard to the

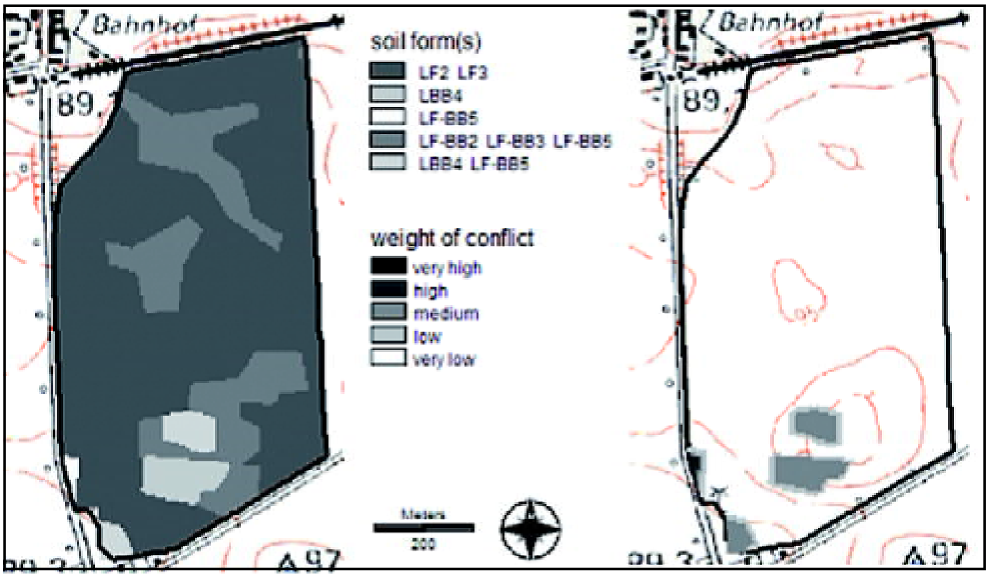

Fig. 1. Map of soil forms after integration of *BS* map information into the extended *BÜK300* map with the TBM (left) and classified *weights of conflicts* (right); (see tab. 2. for explanation of abbreviations)

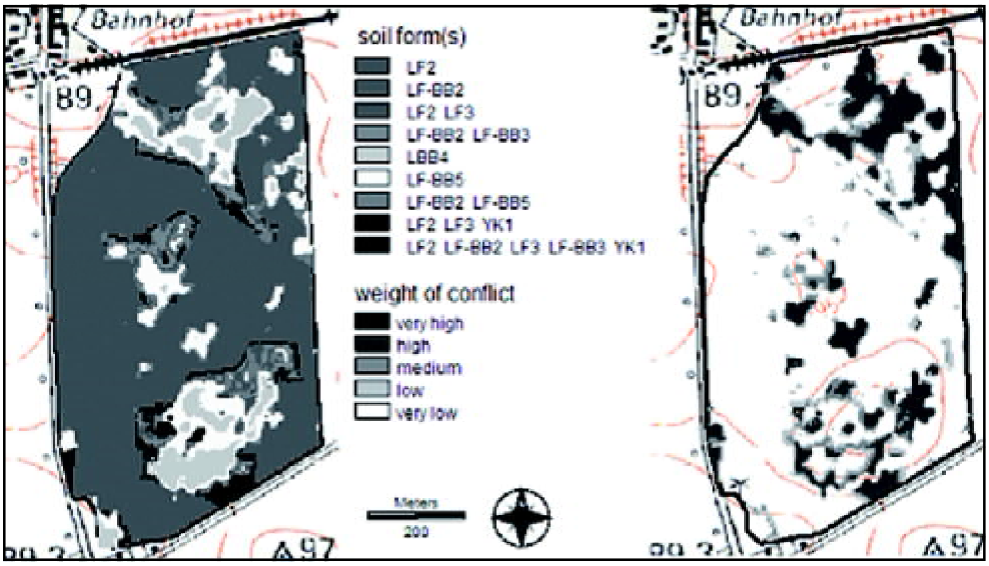

Fig. 2. Map of soil forms after integration of EC_a interpretation (scheme 1) into the updated map of soil forms with the TBM (left) and classified *weights of conflicts* (right); (see tab. 2 for explanation of abbreviations)

conflict value *woc*, 5% *medium*, and 6% *low*, respectively. After the update, the legend of soil forms contains 9 categories, of which 4 are spatially important.

The regions with high *woc* are mainly regions, where the first update shows highest *mob* values for soil forms LF_2 and LF_3. The integration of EC_a data now supports the hypothesis that rather the soil forms lBB_4 or $LF\text{-}BB_5$ occur in these areas. In the central northern area the update suggests geometrical corrections of the polygon delineations. However, at the eastern field border an area with these soil forms is completely newly introduced.

The result of using the second EC_a interpretation scheme is shown in fig. 3 (left). The map legend contains 8 categories, of which 4 are spatially important. The spatial structures of *woc* are identical with those of the first interpretation scheme and therefore are not shown again. Instead, to ease visual comparison of the results, a greyscale image of an aerial photography taken in spring 2003 is given in fig. 3 (right). The crop grown on the field is winter wheat. The dark grey areas in the image represent dense coverage with plant leaves. The white areas represent bare soil surface because of low plant densities. The rather diffuse bright areas in the northern and southern part are caused by poor crop establishment due to very sandy soils. However, in the central part the missing crop is caused by water logging on frozen soil in local depressions over winter and the subsequent death of plants (notice the brighter ice-caused ring structures around white areas).

While the spatial structures of updated soil borders seem to be similar to some extent, the respective hypotheses for the regions within these borders as reflected by

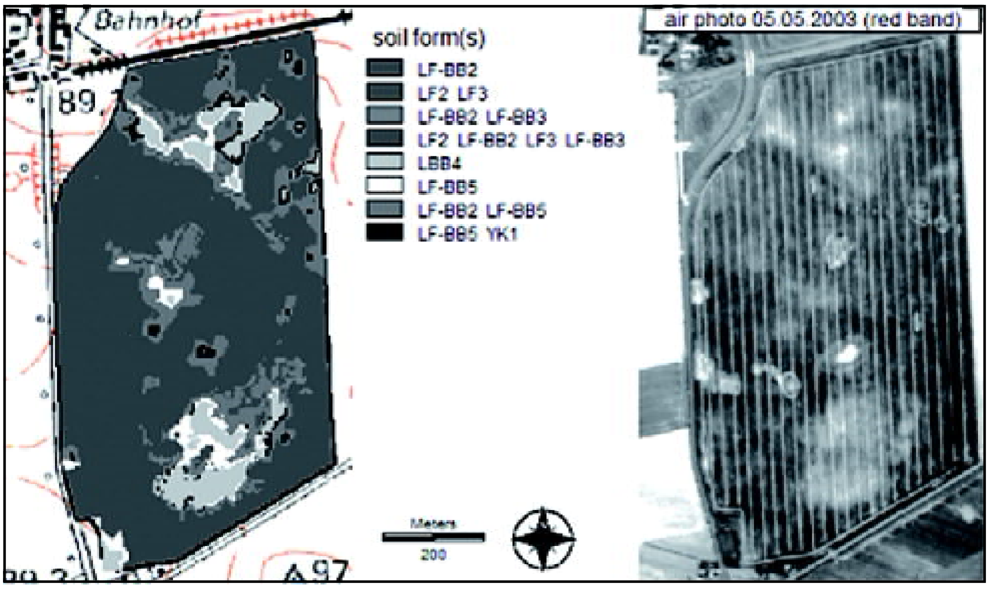

Fig. 3. Map of soil forms after integration of EC$_a$ interpretation (scheme 2) into the updated map of soil forms with the TBM (left) and aerial photograph taken in spring 2003 (right); (see tab. 2 for explanation of abbreviations)

the different EC$_a$ interpretation schemes differ. Table 3 gives a quantitative analysis of the supposed spatial coverage of different soil forms (or a combination of these) as a result of the successive, different steps with the TBM.

The comparison of the results for the last map update step, the integration of interpretation of EC$_a$ data according to two different schemes, has two main results: both approaches (1) reduce the area, where LF$_2$ ad LF$_3$ hypotheses get the highest belief support, and (2) subdivide 20% of the field into several new legend units, where the first update process supports the combined set of LF-BB$_2$, LF-BB$_3$ and LF-BB$_5$ soil forms.

With regard to the first result, the application of the EC$_a$ (1) scheme introduces larger areas of LF-BB$_5$ soil forms, represented by bright shades in fig. 2, and the legend category LF$_2$ / LF-BB$_5$, although to a smaller extent. This legend category has a darker shade. The EC$_a$ (2) scheme supports the legend unit LF$_2$ / LF-BB$_5$ to a larger extent, what explains the most striking visual difference between both maps. Additionally, this scheme supports the belief that some areas are covered with YK$_1$ soils (black).

With regard to the second result, two differences between the EC$_a$ interpretation schemes occur for roughly one third of the area with legend category LF-BB$_2$, LF-BB$_3$ and LF-BB$_5$, while on two thirds of the area with this legend category, both schemes show the same results. For the larger part of differing results, EC$_a$ (1)

Table 3

Spatial shares of hypotheses about soil forms on the study field with highest *mob* values for combination of different data sources with the *Transferable Belief Model*

Soil form							Data sources user				
YK_1	LF_2	LF-BB$_2$	LF_3	LF-BB$_3$	lBB$_4$	LF-BB$_5$	BÜK300	BÜK300 literature	BÜK300 literature BS	BÜK300 literature BS EC_a (1)	BÜK300 literature BS EC_a (2)
o-u/p-sö	p-sö/f-s		p-sö/p-ls		p-s/f-s	p-s/p-ls					
	x									< 0.1%	
		x								3%	3%
	x	x					100%	100%			
	x		x						74%	64%	67%
		x		x						2%	2%
	x	x	x	x							2%
					x				3%	6%	7%
						x			0.4%	13%	4%
		x				x				7%	14%
		x		x		x			20%		
					x	x			2%		
x	x		x							2%	
x	x	x	x	x						2%	
x						x					2%

Source: Author's own data.

eleminates the LF-BB2 and LF-BB3 soil forms from the legend category. Both soil types occur on sand loess parent material. By this, only LF-BB_5 remains in the legend category, what again results in a lighter appearance of the map. EC_a (2) has this effect on only half of this area. The other half still contains LF-BB_2 in the legend category, a distinctively different soil from a genetical/taxonomical point of view. The second difference is the interpretation of high EC_a values as YK_1 soil forms (colluvial soils) by the first scheme. As obvious from table 2, the second scheme has only soils on sand loess parent material as possibilities for high EC_a values. This explains most of the differences on the maps with regard to black areas (fig. 2 & fig. 3).

Although it is only relevant for a rather small part of the whole field, another result is interesting from the point of view of introduction of new methods in soil science and rational discussion in digital soil mapping: The EC_a (2) scheme has only half of the area with high belief values for YK_1 soils if compared to the EC_a (1) scheme. For EC_a (2) these occur partly at transition zones from sandy parent material into sand loess areas, partly as small islands. Especially for these islands the EC_a (1) scheme shows LF-BB_5 soil forms, occuring on sandy material. This is an important difference with regard not only to soil classification and geology, but also with regard to possible decisions for land use on these sites (agricultural production potential), or the environmental importance of such soils (nutrient balances, biodiversity). The airphoto in fig. 3 indicates that rather the scheme EC_a (2) interpretes the EC_a values in a way that renders the real situation on the field, as the water-logging areas occur in local depressions where colluvial material is accumulated. Additional, field validation resulted in YK_1 soil forms for these depressions. Further research could use the explicit interpretation scheme from this study to analyze similar patterns in other regions. This should improve our knowledge on the EM38 sensing method for reinterpretation of soil maps.

Summary

Future demand for more detailed soil maps for rational use of natural resources in so different areas as agriculture production, environmental protection, and/or general spatial planning, can only be met, if efficient update procedures exist (7). These update procedures will extent existing maps by integration of new data from soil surveys and other spatial and non-spatial data sources.

However, to avoid the update procedure to be perceived as a `black-box`, interpretation of the different data sources should be made explicit to enhance discussion among the experts involved, and ease learning and education in extension services. As well, it is necessary to be able to account for varying reliability of data sources used in the update procedure. Reliability may depend on the age of the data source, the data sources themselves, processing methods used, interpretations etc. Reliability assessment may change with regard to the very specific mapping project and data sources used.

This paper shows the possibility to represent existing knowledge about soil with belief structures. Both spatial as well as non-spatial data are used to develop a large

scale map of soil forms. The update procedure for the beliefs with the TBM allows for reliability weighting. More important, the belief update results in a quantitative measure for conflicts with regard to beliefs in different, mutually excluding hypotheses. Areas with high weights of conflict after the update procedure can be treated as the target areas for directing available resources for more detailed investigation. In this study, additional research could be directed to solve conflicts between data sources to roughly 20 % of the study field. However, concentration on taxonomically contradicting soil forms could further focus the research activities.

The value of an explicit interpretation scheme for a rather new soil variable is demonstrated for the study area with the example for the apparent electrical conductivity (EC_a). While assuming the standard theory of how to interpret EC_a values with regard to soil parent materials or soil types, the results of data combination can introduce significant errors, although not spatially dominating in this example. However, the explicity of the interpretation and the spatial structures of conflict will ease communication of the results and hopefully bring more rational discussion into the map update reflecting underlying processes.

Abstract

Soil map update in the future with regard to scale and/or content will more and more see the interpretation of non-soil data, than results from extensive new field and laboratory work. Geographic Information Systems (GIS), remote and proximate sensing devices will become increasingly important. To keep transparent the process of data interpretation and map update, information about uncertainty and partial knowledge, as well as conflicts should be integrated into the maps. This integration can be done with belief structures. For an agricultural field (46 ha) maps of different age, scale and content, as well as data of the apparent electromagnetical conductivity (EC_a) were integrated with the Transferable Belief Model (TBM). The introduction of high-resolution soil information from EC_a measurements shows different, more or less compact areas of the field, where the combination of the beliefs of prevailing soil forms results in conflicts. This affected approximately 20% of the field. Different interpretation schemes for the EC_a data with regard to soil forms resulted in different hypotheses for these conflicting areas, however, they did not change the spatial structure of the resulting soil map polygon borders, or the zones with conflicting data.

Streszczenie

STWORZENIE NOWEJ INFORMACJI O GLEBIE PRZEZ KOMBINACJĘ ŹRÓDEŁ DANYCH O RÓŻNEJ TREŚCI I SKALI ZA POMOCĄ SIP I STRUKTUR PRZEKONAŃ

W przyszłości aktualizacja map glebowych najprawdopodobniej będzie prowadzona z mniejszym wykorzystaniem wyników prac terenowych i laboratoryjnych, a raczej opierać się będzie na interpretacji danych nieglebowych, takich jak np. dane ze źródeł teledetekcji, przewodności elektrycznej gleb, cyfrowego modelu terenowego. W związku z tym systemy informacji przestrzennej (SIP) będą odgrywać coraz większą rolę w tym procesie. Z czasem mapy glebowe w formie cyfrowej będą zastępować tradycyjne mapy analogowe (papierowe). Mapy cyfrowe oferują możliwość integrowania, zapisywania i dostarczania większej ilości danych niż mapy analogowe. Dane te mogą być wykorzystywane dla potrzeb analiz, jak i wizualizacji. Jednakże aby zachować jasność i zrozumiałość ciągu integracji danych i aktualizacji map, należy uwzględnić informacje dotyczące niepewności danych lub niekompletności wiedzy. Konflikty pomiędzy różnymi źródłami danych powinny również zostać zintegrowane w postaci odpowiedniego atrybutu na mapie cyfrowej.

Reprezentację wiedzy i niepewności modeli oraz danych cyfrowych można realizować różnymi metodami. Jedna z nich wykorzystuje strukturę przekonań, np. metoda Transferable Belief Model (TBM); (15). Metoda ta pozwala na udostępnienie dwóch kategorii informacji dla poszczególnego miejsca na mapie (piksel rastrowy lub poligon wektorowy): pierwsza kategoria dotyczy hipotezy co do typów glebowych w danym miejscu. Druga kategoria informacji podaje dane opisujące miarę przekonania, że hipoteza ta naprawdę potwierdza się w rzeczywistości. Metoda TBM pozwala też na postawienie i wykorzystywanie więcej niż tylko jednej hipotezy dla każdego piksela w różnych warstwach informacyjnych w SIP. Razem z hipotezami łączone są poszczególne wartości przekonań. W ciągu integracji warstw informacyjnych w modelu TBM mogą występować konflikty pomiędzy różnymi hipotezami i zostają one reprezentowane przez ilościową wartość konfliktów. Wartość ta wyliczona jest z wartości przekonań poszczególnych hipotez.

Aby wyjaśnić zasady działania modelu TBM, artykuł niniejszy przedstawia wirtualną aktualizację danych z historycznej mapy glebowej. Aktualizację wykonano za pomocą danych pomiarowych plonów, pozwalających skorygować treść mapy glebowej. Stara mapa ma niską wiarogodność z powodu wieku, a mapa zmienności plonów jest bardziej wiarygodnym odzwierciedleniem zmienności glebowej przy wyższej jednocześnie rozdzielczości danych. Jednak jest ona jedynie interpretacją plonów jako wskaźnika jakości gleby. Z tego powodu obydwie mapy nie są w pełni wiarygodne. Rezultatem łączenia obu warstw danych mogą być dwie hipotezy dla jednego miejsca (np. „gleby urodzajne" na starej mapie, a „gleby nieurodzajne" antycypowane na pod-

stawie mapy plonów). Natomiast wartości przekonań pozwolą na ostateczną decyzję co do interpretacji jakości gleb. Wielkość wartości konfliktu pomiędzy wykluczającymi się hipotezami, że dodatkowe badania i pomiary powinny koncentrować się na spornym obszarze. Główna część artykułu przedstawia wyniki integracji starych i nowych danych glebowych dla wybranego pola uprawnego (46 ha) zlokalizowanego na południe od Berlina (Niemcy). Zagadnienie to wykonywano z wykorzystaniem modelu TBM i SIP. Zinterpretowano i połączono dwie mapy glebowe (1 : 300 000 i 1 : 5 000), informacje z literatury oraz aktualne dane pozornej przewodności elektrycznej gleby (ECa). Model TBM pozwala sprowadzić ogólną, nieprzestrzenną informację z literatury do istniejącej mapy glebowej. W wyniku tych działań został powiększony zestaw możliwych hipotez dla danego regionu. Zakłada się, że jeśli połączono mapy w różnych skalach i dodatkowo obydwie mapy są wiarogodne, to występujące konflikty zostaną interpretowane jako konflikty skal. Jeśli natomiast łączono mapy w podobnych skalach, konflikty wskazują na poważne niezgodności treści map. Dodatkowo powinny być skierowane do obu obszarów konfliktu, aby uzyskać więcej informacji. Informacje te mogą być wykorzystane, aby polepszyć wiarygodność mapy ostatecznej. Artykuł niniejszy przedstawia, jak różne schematy interpretacji wartości ECa mogą spowodować różnice na mapach ostatecznych. Mimo że różnice te występowały tylko na małym obszarze badanego terenu istotne jest ukazanie, jak ważne jest przedstawienie i uzasadnienie samego procesu interpretacji nowych źródeł danych w gleboznawstwie. Cała procedura aktualizacji map glebowych z wykorzystaniem SIP może być niezrozumiała, jeśli nie przedstawiono procesu interpretacji wykorzystanych danych. Może to rodzić wątpliwości co do wiarygodności treści ostatecznej postaci aktualizowanej mapy. Ograniczy to zarówno przepływ wiedzy pomiędzy ekspertami z różnych dziedzin, jak i ogólnie rozwój wiedzy o glebach.

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