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Plausibility test of conceptual soil maps using relief parameters

Markus Möller [a,*], Thomas Koschitzki [b], Klaus-Jörg Hartmann [c], Reinhold Jahn [d]

[a] University Halle-Wittenberg, Department of Remote Sensing and Cartography, Von-Seckendorff-Platz 4, 06120 Halle (Saale), Germany
[b] Geoflux GbR, Lessingstr. 37, 06114 Halle (Saale), Germany
[c] State Institute for Geology and Natural Resources Saxony-Anhalt, Köthener Str. 38, 06118 Halle (Saale), Germany
[d] University Halle-Wittenberg, Department of Soil Science and Soil Conservation, Von-Seckendorff-Platz 3, 06120 Halle (Saale), Germany

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ABSTRACT

The motivation for this article results from the fact that conceptual soil maps show oftentimes inaccuracies with regard to soil unit boundaries or misfits between original paper and actual soil-related information. Using the example of a German conceptual soil map (CSM), we introduce a procedure which could be considered as a framework for testing the terrain-related plausibility applied within a genetic based soil-ordering system. Framework means that all tests and the underlying methods can be adapted to specific targets. The procedure enables both reproducible integration of expert knowledge and application of statistically sound methods.

The CSM of the German Federal State of Saxony-Anhalt was tested regarding the plausibility of colluvial and fluvial process domains. The plausibility test consists of four steps and was exemplified on a study area of 100 km^2. First, basic relief parameters were combined to the explaining relief parameters *Floodplain Index (FPI)* and *Mass Balance Index (MBI)* enabling a classification of process domains by relative descriptions. Second, relief parameters and aggregated CSM soil units were integrated to soil-terrain objects (STO) executing a region-growing segmentation algorithm. In the third step, the one-dimensional *MBI* or *FPI* feature space of STO entities were clustered by using the K-means algorithm. The fourth step comprises the expert-based selection of reference clusters (RC) representing colluvial and fluvial process domains accepted as being true. Then, empirical cumulative distribution functions (ECDF) of RC and remaining soil unit-related STO clusters were compared by a traditional goodness-of-fit test whose suitability for estimation of terrain-related CSM plausibility is shown. Finally, the resulting ECDF distances were visualized.

The testing procedure could also be used for the supervised selection of appropriate samples for automatic classification algorithms. The data integration approach is generally suitable for adopting existing data in computer-based systems.

1. Introduction

Conceptual soil maps (CSM) are the result of an expert-based integration process wherein different soil-related information or already existing older soil maps are combined by soil surveyors (Dobos and Hengl, 2009). The resulting soil maps "are representations of structured knowledge" (Bui, 2004). The data integration process is mainly guided by the ordering system. Genetic soil-ordering concepts are based on generally accepted perceptions of soil genesis and allow more expert-based interpretation than classification systems where threshold defined diagnostic horizons, features and the horizon sequences determine soil units (Albrecht et al., 2005; Buol et al., 2003).

A German CSM example is the preliminary soil map 1:50,000 of Saxony-Anhalt (in German: "Vorläufige Bodenkarte 1:50,000" or VBK 50; Hartmann, 2005, 2006). The VBK 50 map results from an expert-based integration process where older soil maps were semantically transferred into the actual (genetic) German soil ordering system (Ad-hoc AG, 2005). The soil map contains typical CSM inaccuracies. First, misfits between original paper and actual, more accurate soil-related information exist. Second, locations of systematic soil unit boundaries are often incorrect due to their subjective delineation. This can be observed especially between areas of fluvial and terrestrial process domains. A special problem is related to the attribute structure of the used older soil maps which were the basis of the CSM creation (Deumlich et al., 1998; Müller and Volk, 2001). The attributes describe heterogeneous soil units of genetically linked soils. That means that the occurrence of some – especially colluvial – soil units are only listed in the attribute table but not represent polygons (Möller, 2008).

The mentioned inaccuracies are mostly terrain-related and concern especially colluvial and fluvial process domains. Information about surface topography can nowadays be derived from easily accessible digital elevation models (DEM) in different spatial resolutions and accuracies (Hengl and MacMillan, 2009). Thus, the main objective of this study is

* Corresponding author. Tel.: +49 345 5526025; fax: +49 345 2394019.
E-mail address: markus.moeller@geo.uni-halle.de (M. Möller).
URL: http://www.geo.uni-halle.de/geofern/mitglieder/moeller/ (M. Möller).

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the development and application of a procedure testing the colluvial and fluvial plausibility of VBK 50. Furthermore, heterogeneous soil units should be geometrically disaggregated regarding the occurrence of colluvial process domains.

In this study, the plausibility test is demonstrated on the example of the German topographic map TK25 4336 Könnern at a scale of 1:25,000 with an area of about 100 km^2. In a joint project of a state authority, a scientific institution and an engineering office, the procedure was applied on the total area of the German Federal State of Saxony-Anhalt (≈20,000 km^2). The project's outcome can be considered as a compromise solution, in which pedological and digital soil mapping (DSM) expertise were balanced.

We are using the term *plausibility* instead of *quality* or *accuracy*. Quality and accuracy are related to international standards for geodata (e.g. ISO 19138, 2006). This should help data producers objectively describe the quality of data and determine its quality using statistical calculation rather than subjective estimation. Although we support the utilization of statistical quality measures, we also recognize the need for possibilities to deal with expert knowledge in a reproducible manner (see Deumlich et al., 2010). The integrating result of subjective and objective quality to assess the soil map's goodness we refer to as *plausibility*.

In this study, plausibility is considered as distance between reference and test distributions of explaining relief parameters. We show how basic relief parameters can be combined to specific indices which explain the occurrence of colluvial and fluvial process domains. Furthermore, we demonstrate how reference distributions can be defined by expert-knowledge in a transparent and traceable manner. Finally, the suitability of a traditional goodness-of-fit-test for comparing relief parameters' distributions is investigated.

2. Materials and methods

2.1. Study site

The study area is situated in the German Federal State of Saxony-Anhalt and represents heterogeneous soil and relief conditions (Fig. 1, Table 1; Möller et al., 2008). The formation of parent materials, relief and soil formation was connected with glacial and periglacial conditions during the Saalian and Weichselian glacial stages where plateaus and floodplains were shaped. Plateaus and plateau margins are mainly covered by Weichselian loess and Saalian moraine material. There, calcareous Ah/C and black soils dominate (Pararendzina, Tschernosem). Where older sandstones, clay or limestones of mainly

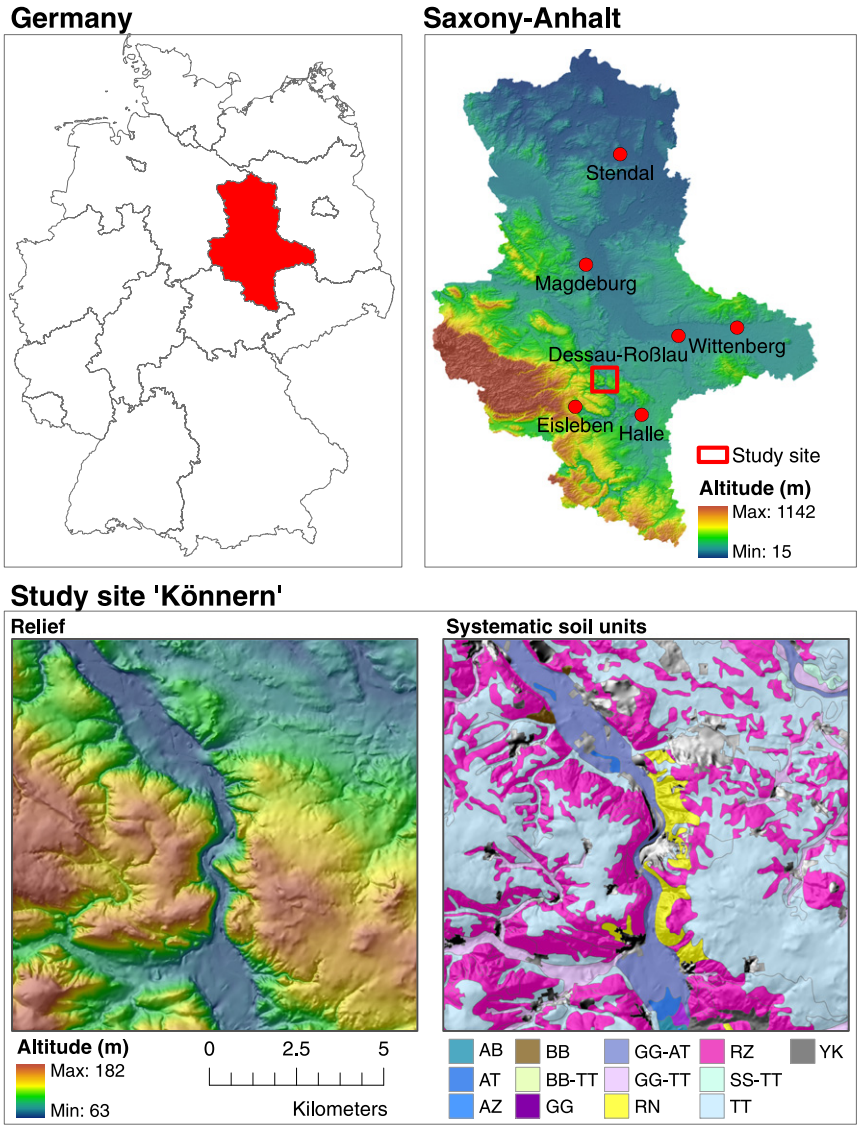

Fig. 1. Study site location as well as its soil (see Table 1) and terrain conditions (Data sources: Soil units — http://www.lagb.sachsen-anhalt.de | DEM — http://www.lvermgeo.sachsen-anhalt.de).