

Using Relief Parameters in a Discriminant Analysis to Stratify Geological Areas of Different Spatial Variability of Soil Properties

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Spatial distribution of soil properties in landscape is controlled by the soil forming factors relief, parent material, climate, organism and time. Although this relation is a paradigm in soil survey, it is rarely considered in the analysis of spatial variability of soil properties. The objective of this paper is to show how discriminant analysis can be used to identify on an objective basis the soil depth at which geology changes. This information can then be used for a better soil survey and geostatistical regionalization of soil properties. The study area was a 1.5km² soilscape 50km north of Munich with high variability in parent material and relief. Altitude varied from 445 to 498m above sea level. Topography included valleys in all directions and asymmetric slopes with different aspects. Sediments of the Tertiary period ranged from gravely and sandy fluvial sediments to silty and clayey sediments over short distances. They are partly covered by Pleistocene loess of variable thickness (0-2m) and colluvial material. Field survey was done on 450 nodes of a rectangular 50x50m grid and fundamental soil properties were measured for each classified soil horizon. Relief parameters were calculated using a Digital Elevation Model (DEM) derived from more than 4000 elevation measurements.

A discriminant analysis was performed to distinguish areas of sediments of the Tertiary period (TS) from areas with Quaternary sediments (QS). For this, soil horizons, which were classified without any doubt to TS (class 1) resp. to QS (class 2) as parent material in the field survey, were selected as test data set. The 86 soil horizons for class 1 and 496 soil horizons of the class 2 were obtained. They were weighted by their different horizon thicknesses to account for their representation within a soil. Beside several relief parameters, soil depth of the horizons was used as discrimination variable. With elevation above sea level, soil depth, slope and upslope watershed area as independent variables, it was possible to reclassify 86.6% of class 1 and 85.4% of class 2 by the discriminant analysis. The significance for discrimination of these variables can be well explained by the geological processes forming the soilscape of the study area. Dissolving the discriminant functions by the soil depth and applying the result to the DEM yields a map of the boundary depth (BD) between the TS and QS. Thus, transforming the result to the parameter BD gives several advantages: With BD a mappable visualization of the classification function was possible. Finally, the BD was used to divide the study area-dependent on the soil depth of interest into two strata, which allowed variogram calculations for each strata and soil depth separately. Thus, the variograms for pH, organic carbon and soil texture showed in the subsoil much higher spatial variability for the strata of class 1. Consequently, four times more measurement points must be taken for the strata TS than for the strata QS to reach the same precision when interpolating e.g. soil texture in subsoil. This confirms again the necessity to include relief and geological information to geostatistical analysis.