Digital soil mapping using geomorphon as a predictive terrain attribute

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Introduction

Digital soil mapping (DSM) geographic information systems (GIS) tools are essential for characterizing landscape components and the relationship between soil classes and their attributes. Soils properties vary across landscapes following patterns related to topography. These topographic patterns can be characterized by digital elevation model (DEM) derived covariates, such as slope, aspect and curvature. Geomorphons presents a novel method for landform mapping and classification. It is based on the principle of pattern recognition, and can be calculated by a flexible procedure, at different scales, using different look out distances, also called search radius (*L*). The goal of this study was to evaluate Geomorphon landform classification as a terrain based covariate for soil class prediction by neural networks (ANN's).

Material and methods

Models were generated for landscape attributes, such as altimetry, slope, curvature, combined topographic index, euclidean distance, clay minerals, iron oxide, normalized difference vegetation index (NDVI), geology and different sizes of search radius (*L*) to calculate the geomorphons (3, 5, 10, 15, 20, 25, 30, 35, 40, 45, 50, 100, 150, 300 and 500 pixels).

The most common forms generated by the Geomorphon map are represented by FL-flat, SL-slope, PK-peak, PT-pit, RI-ridge, VL-valley, SL-shoulder, FS-footslope, SP-spur, HL-hollow (Fig. 1).

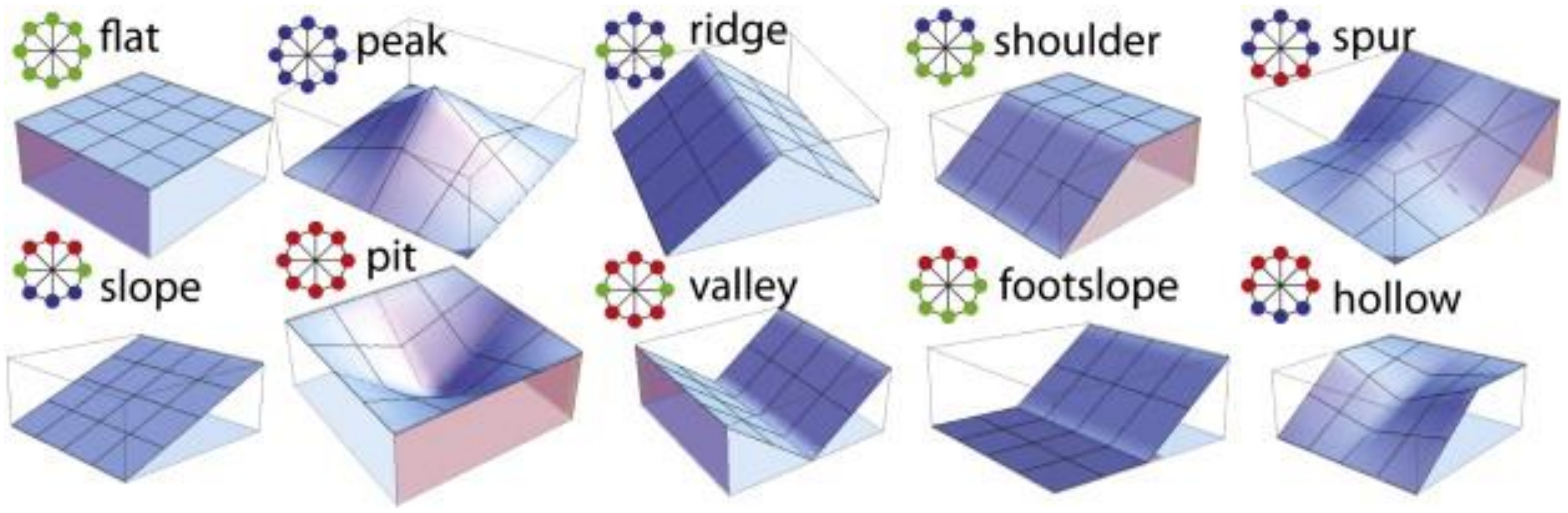

Fig.1. Tem most commom landforms

All the models for landscape attributes were generated with 30 m pixel resolution, and these variables correspond to neurons in the input layer of the neural networks classification. For the ANN analysis were generated 16 sets with different combination of input variables, wherein each set contains a Geomorphon with different size of search radius (*L*). The appropriate Geomorphon was selected based on statistical index (kappa, overall and variance). The approach was based on assessing assumed pedogenic relationships with attributes that represent redistribution of water on landscapes.

Results and Discussion

The predominant soils were: Oxisols, Ultisols, Inceptisols with Aquents and other Entisols. The soil classes represent the output layer of the neural network classification. The input layer to each one of the sixteen ANN sets corresponding to the terrain co-variables and one Geomorphon (calculated with different size of search radius - *L*). According to the analysis, the best performance was observed for Geomorphon calculated with 45 pixels of search radius (Fig. 2).

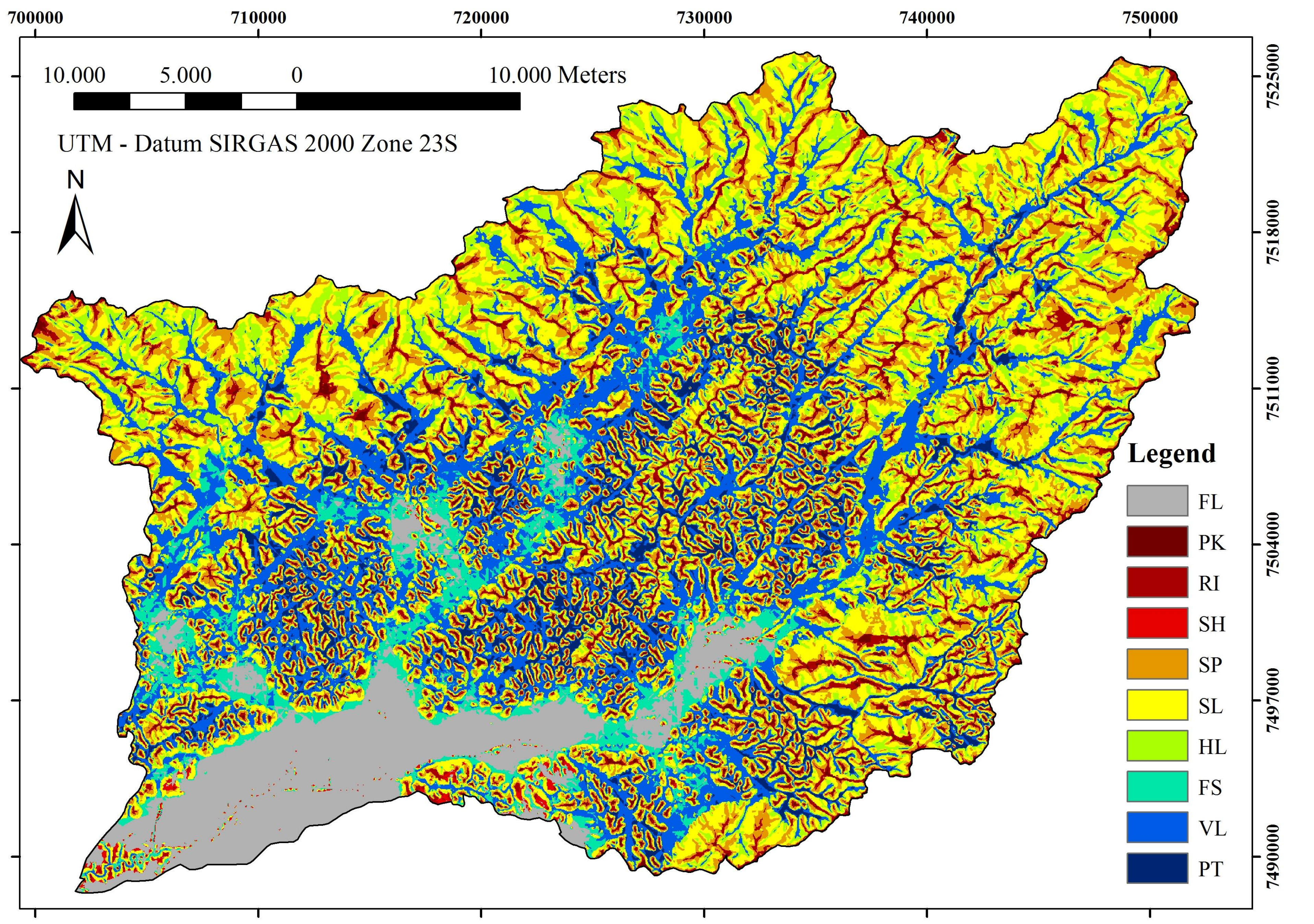

Fig. 2. Geomorphon calculated with 45 pixels of search radius

The performance of the sets by ANN's classification was evaluated by statistical parameters obtained from a confusion matrix, such as kappa index and variance (Table 1).

Table 1. Statistical indexes for the 16 ANN's sets trained

Set	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
L	0	3	5	10	15	20	25	30	35	40	45	50	100	150	300	500
Kappa	0.709	0.735	0.713	0.716	0.690	0.703	0.662	0.680	0.685	0.686	0.741	0.740	0.717	0.704	0.716	0.719
Variance	1.78	1.67	1.76	1.76	1.87	1.80	1.96	1.88	1.88	1.86	1.66	1.65	1.75	1.79	1.76	1.75

Conclusions

The results of this study illustrates a potential usefulness of Geomorphons for relating soil classes to landscapes. Geomorphons relate to landforms that correlate to geomorpho-pedological processes leading to soil differences. These classes are easy to calculate and may prove to be beneficial covariates for digital soil mapping.