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Automated geomorphological mapping using Multiple Point Geostatistics

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The geomorphological map is an important tool for studying land-surface processes. Automated mapping ensures a consistent mapping scheme with a reduced field survey time. Current techniques that use one or two point statistics of topographical attributes (e.g. cluster analysis, variogram-based approaches) are inadequate in reproducing complex, repetitive or curvilinear landform patterns. In this study, we propose the use of Multiple Point Geostatistics (MPG), where geomorphology at each map location is assigned using information from that location and multiple locations in its neighborhood. Information used includes derivatives of the digital elevation model and geomorphology mapped in the neighborhood. Here, we focus on the configuration of the MPG technique in terms of suitable topographical attributes to be used in mapping and the assessment of mapping accuracy. The approach is evaluated using a dataset from the French Alps.

In the first procedural step, spatial statistics of the geomorphologic units is retrieved from a training data set, consisting of 37.5 m2 resolution DEM and a field map of geomorphology in a small training area. For each grid cell in the training data set, the geomorphological unit of the grid cell and a set of topographical attributes (i.e. a pattern) of the grid cell is stored in a frequency database. The set of topographical attributes stored is chosen such that it represents criteria used in field mapping; for instances, topographical gradient, upstream area, or geomorphological units mapped in the neighborhood of the cell. Continuous information (e.g. slope) is converted to categorical data (slope class), which is required in the MPG approach.

The second step is to use the knowledge stored in the frequency database for mapping. The algorithm reads a set of attribute classes from a classification target cell and its surrounding cells taking account of the multiple-point attribute patterns. Frequencies of these patterns are retrieved from the frequency database and converted to a categorial probability distribution giving the probability for each geomorphological unit class in the cell. The algorithm draws a possible unit class from this distribution and assigns the outcome to the target cell. This procedure is iteratively done for each cell in the mapping area.

Results from the MPG-based mapping routine are evaluated against the field map. It is shown that this technique is capable of reproducing the geomorphological pattern as present in the field map with 50% overall accuracy, using 10 classes of relative elevation to the local base level, slope gradient and distance of cells to 20% of the highest elevation as well as majority of geomorphology type at the neighbouring cells as mapping criteria. It can be concluded that these topographical attributes are key variables in the automated geomorphological mapping. The geomorphological units that are easily mapped out with high accuracy are debris slope, river plain and colluvium.