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Mapping geomorphology based on the information from existing geomorphological maps with a multiple-point geostatistics technique

Lucie Babel, Ekkamol Vannametee, Martin Hendriks, Jasper Schuur, Steven de Jong, Marc Bierkens, and Derek Karssenberg

Utrecht University, Physical Geography, Netherlands (e.vannametee@uu.nl)

Geomorphological maps are valuable tools for studying land surface processes. Information obtained from the field geomorphological maps can be, in turn, used in mapping geomorphology at another area. In this study, we present an application of the multiple-point geostatistics (MPG) technique in geomorphological mapping. This technique makes use of the field geomorphological maps, together with the topographical data obtained from the Digital Elevation Model (DEM), to derive the knowledge on the formation of different geomorphological units in the landscape (e.g. river terrace, alluvial fan, badlands) as a basis in mapping areas with unknown geomorphology. This approach starts from characterizing the occurrence of each geomorphological class as a function of land surface attributes (i.e. attribute pattern), which consists of DEM derivatives discretized into classes (e.g. slope class) observed at that cell location, and geomorphology at multiple neighboring locations. The latter gives information on the spatial relation between geomorphological units. Number of cell occurrences per geomorphological class per attribute pattern is counted and stored in the frequency database, which will be subsequently used in the mapping. In the mapping stage, the algorithm assigns a realization of a geomorphological class to the target mapping cell, based on the probability function of geomorphological occurrences conditioned to the observed attribute pattern at the target mapping cell, as retrieved from the frequency database.

The approach is tested to map the geomorphology in the 280 km^2 Buëch catchment, French Alps. We use 4 morphometric attributes, extracted from a 37.5-m DEM resolution (i.e. height above the nearest drainage, slope gradient, profile curvature, and slope variability); and 2 non-morphometric attributes (i.e. geomorphology observed at 1-cell and 10-cells downstream from a cell of interest). Mapping is done using different frequency databases created from different training areas with sizes ranging between 7-28 km^2 (2.5-10% of the mapping area). The MPG technique yields the geomorphological map with the highest cell accuracy of 51.2% evaluated against the field geomorphological map, using the training image size with 10% of the mapping area. The unit mapped with the highest accuracy is the debris slope, while hogback and glacis were mapped with the lowest accuracy. The mapping accuracy is highest for training areas with a size of 7.5-10% of the total area. Reducing the size of the training images resulted in a decreased mapping quality, as the frequency database only represents local characteristics of the geomorphology that are not representative for other areas. Increasing the size of training images beyond this range may not considerably increase the mapping quality. This will, instead, result in a redundancy of information and more variations in geomorphological class occurrences per attribute patterns in the frequency database, reducing the capability to discriminate between geomorphological units.