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Computation, validation and sensitivity of the DTM-derived geomorphic parameters: the case of Stream-Length Gradient Index

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Quantitative geomorphic analysis from DTMs has become a common procedure for creating and analysing geothematic maps. Nevertheless, it is often neglected that the accuracy of interpretations generally depends on the accuracy of the DTMs itself (i.e. both the ground resolution and interpolation method). In the case of the DTM-derived quantitative geomorphic indices different open-questions are still the object of a suggestive debate. One of the crucial questions is the objective identification/characterization of processes and landforms responsible for anomalous values of the parameter analysed; particularly, in those cases where either the same process can result in different anomalies or the same anomalous value can be related to different processes/landforms.
In this frame, our work is aimed at providing a new geostatistical methodology to validate the computation goodness of the geomorphic indices from DTMs and to interpret the anomalous values in their spatial distribution. We applied the proposed methodology to the computation and spatial analysis of the DTM-derived Stream-Length Gradient Index (SL Index). Since the SL Index is a proxy of the Stream-Power per Unit Length and is proportional to the total stream-power available at a particular channel reach, it is very sensitive to changes in river gradient and represents a practical tool to highlight perturbations along the longitudinal profiles. In addition to the known relationship between rock resistance and SL Index, the latter may be used to detect the surface effects of fault activity through anomalously high index values on a specific rock type. Recently, some researches outlined that in small river basins extreme values of the SL Index seem to reflect the topographic fingerprint of slope failures directly reaching the stream channels.
In this work we created a statistical, well-constrained SL Index map within the Upper Tena river valley, which occupies approximately 47 km2 in the mountainous sector of the central Spanish Pyrenees. The procedure proposed here is aimed at distinguishing objectively the averaged response of the SL Index values to lithology, fault displacements and slope failures. As for statistical interpolation of DTM-derived SL Index values, we proceeded in two steps: 1) computation of the experimental variogram and its best-related theoretic fit that took also into account anisotropies of the river patterns; this latter was used in the second interpolation procedure; 2) statistical validation of different interpolators (i.e. O-Kriging, U-Kriging, IDW, NeN, TLI) basing on the leave-one-out cross-validation. Finally, once obtained the SL Index map, we applied a map filtering using the representative "range-values" (RV) for all processes in order to distinguish the different topographic fingerprints of lithology, fault displacements and slope failures.
Encouraging results suggest the goodness of the proposed methodology that validates at the same time both the computation and the spatial analysis of a DTM-derived quantitative geomorphic index. Moreover, we have confirmed the sensitivity of the SL Index, calculated from DTMs with different spatial resolution, to detect slope failures within mountainous small river basins.