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Suitability of geomorphological indices for the automatic identification of landslides affecting the drainage network: Examples from the Pyrenees

Guillem Bonaventura Subiela (1), Marta Guinau (1), Jorge Pedro Galve (2), María Ortuño (1), Marc Viaplana-Muzas (3), and José Vicente Pérez-Peña (2)

(1) RISKNAT Group, Geomodels Institute, Department of Earth and Ocean Dynamics, Faculty of Earth Sciences, Universitat de Barcelona, Barcelona, Spain (mguinau@ub.edu), (2) Department of Geodynamics, Faculty of Sciences, Universidad de Granada, Granada, Spain., (3) Institute of Earth Sciences Jaume Almera, ICTJA, CSIC, Lluis Sole i Sabaris s/n, 08028 Barcelona, Spain.

Quantitative geomorphic parameters of drainage networks, like the normalized channel steepness index (Ksn) and the Stream Length-Gradient index (SL), have been demonstrated to be suitable for detecting anomalies on stream-profiles. Ksn and SL indices allow to detect knickpoints, which are generally related to active tectonics, lithological changes and large landslides. In some cases, landslides reaching the river bed generate anomalies with long-stretch influence, which have been defined as knickzones.

Often, this type of studies have to deal with certain limitations such as the difficulty to detect landslides located in the headwaters, the lack of unequivocal signs of the nature of the anomalies and the confusing use of term “anomaly”. In this work, the comparison of different indexes including Ksn, SL and slope derivative, allowed us to better define the term “anomaly”, by: 1) using negative and positive values; 2) comparing these values with those obtained from “ideal” river equilibrium profiles; 3) differentiating between knickzones and knickpoints, and; 4) analysing the intensity and extent of the anomalies.

The proposed methodology consists of computing the Chi, ksn and SL geomorphological indices using a python script and ArcGIS Toolboxes to provide a better localisation of knickpoints and knickzones. Three pilot areas were analysed: La Vall d’Àssua, Romadriu and La Vall de Tor basins (Catalan Axial Pyrenees). The geomorphologic anomalies within these valleys have been compared with the landslide inventory, indicating a well-correlation between anomalies and landslides. Additionally, these geomorphic indices provided the identification of 13 new mass movements, which had not been described before. In this work, the stream-slope derivative and its comparison with that of an ideal profile add new insights for the identification of the landslides near the headwaters of the basins, which were hidden in the Ksn and SL indices analysis.

The proposed methodology shows improvements in the identification of drainage network areas affected by landslides. This should benefit detection and characterization of landslides improving the completeness of landslide inventory maps. Therefore, it should has an impact on the improvement of hazard and risk analysis associated with landslides.