Towards an automatic identification of sediment cascades from geomorphological maps using graph theory

(M.-O. Löwner[1] and J. C.Otto[2])

[1] Institute of Geodesy and Photogrammetry of the Technische Universität Braunschweig, Gaußstrasse 22, 38106 Brunswick, Germany. m-o.loewner@tu-bs.de

[2] Department of Geography and Geology, Universität Salzburg, Hellbrunnerstr. 34, 5020 Salzburg, Austria. Jan-Christoph.Otto@sbg.ac.at

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The concept of a sediment cascade describes the system behaviour of sedimentary flux where mass is transferred along a gravitational gradient from one landform to another. Intrinsic to the cascading structure is the coupling of landforms and processes as well as the temporal storage of sediment along the cascade. Within a pattern of landform distribution sediment cascades link actual process dynamics with past landform evolution. Geomorphological maps represent current landform and process distribution; but they do not explicitly display sediment cascades, landform coupling or sediment transfer. However, this information can be derived by interpretation of the map.

Here we present the deduction of a topological representation of a sediment cascade from a geomorphic map of an high alpine environment in order to extract the pathways of current processes and possible coupling relationships. In order to reach this aim we apply the principles of graph theory. In graph theory a geomorphic map can be viewed as a planar graph *G* whereas its edges represent the boundaries of landforms. A dual graph which has an edge for each plane region of the given planar graph G is used to represent the possible pathways from one landform to its neighbouring sediment sink. Therefore, its edges represent the sediment transfer processes. However, not every neighbour of a landform can serve as a source or sink for sediment. To identify the direction of transport, the altitudinal gradient and the slope inclination needs to be considered. This non topological property needs to be included in the neighbourhood relationships, by representing the sediment cascade as a directed graph.

In a geomorphic map landform boundaries are represented by polygons. In a first step the centroid C_1 is calculated and its 3-dimensional coordinates serves as a starting knot for the graph. Then we search for the lowest point P_{min} of the polygon. Both steps are performed using digital elevation data.

If the centroid C_2 of the adjacent polygon is below P_{min} it is added to the graph by an edge with the direction from C_1 to C_2 and the polygon of C_2 is under investigation. If not we found an abort criterion. This procedure is executed for every landform mapped until everyone is visited once. The outcome is a number of directed graphs with knots representing the landform with all the information stored in the geomorphic map and edges reflecting the possible pathway of sediment in the mapped area.

The presented algorithm is a naive one because no information is used others than the geomorphic map and the digital elevation model. The defined directed graphs will have to be proven against a semantic model ascertaining the validity of each edge concerning the coupling of landforms and processes.