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

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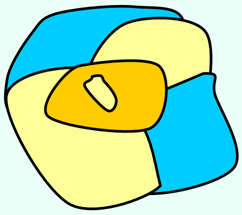
Sediment flux in mountain environments

operates in a cascading system that is primarily driven by gravitational forces and height differences when landforms are neighboring. The assemblage of input and output processes together with intermediate sediment storage produces a typical pattern of coupled landform successions.

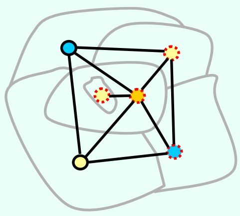
Mountain landscapes are composed of various coupled and decoupled landform complexes that need to be identified in order to asses routes and magnitudes of sediment flux.

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 land-form can serve as a source or sink for sediment. To identify the direction of transport, the altitudinal gradient needs to be considered.



A geomorphic map viewed as a planar graph.



A dual Graph where the edges represent possible interconnections.

A cascade identification algorithm

based on the input of an geomorphologic map and a Digital Terrain Model has been developed:

1. Determine the mean DTM-height for every mapped landform and find all its neighbors

2. For every landform

    If the landform has only one neighbor

        add "Lies Within" and the neighbor's neighbor ID

    End if

    If the landform has more neighbors

        Search for the lowest neighbor

        If there is no neighbor below

            mark the landform with "Is sink"

        End if

        Else

            add the neighbor ID as "Feature Down"

        End if

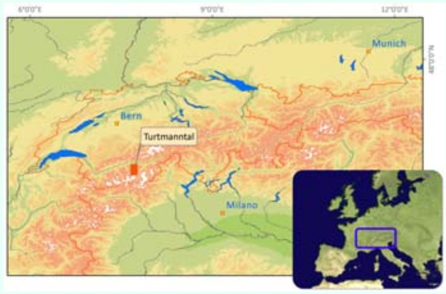
    End if

3 . Find all interconnections (Sediment cascade) of landforms by comparing "FeatureID", "Lies Within ID", "Is Sink ID", and "Feature Down ID"

4. Sort every Sediment cascade by mean DTM-heights

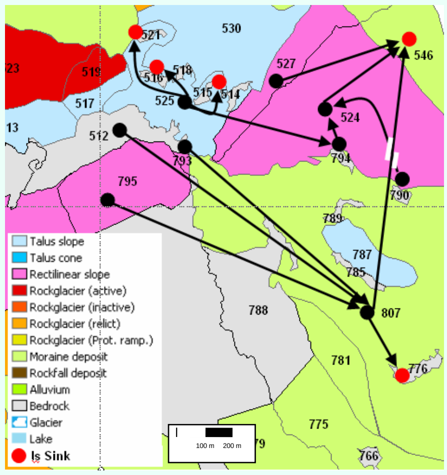
Preliminary results

have been achieved using a geomorphical map of an alpine system in the Turtmanntal (Switzerland). The algorithm was programmed in ArcMap using the Visual Basic for Applications language (VBA).



While analyzing **974** features **50** sediment cascades have been identified with a **median of 18 members**. The longest sediment cascade identified counts 125 features, the 8 shortest only one.

A typical graph of a sediment cascade indicating more a **cascading network** than a chain is shown here. Although the algorithm is strictly based on height differences, more than one feature can be a target for a source. This is due to the marking of small features being included by surrounding ones, i.e. that smaller landforms sit on bigger ones.



Sediment cascade number 30.

Though the Algorithm shows reasonable results, its problems are more easily to determine.

Problems and misinterpretation

of the algorithm applied are listed below:

Of 974 features were

50 marked as Sink though they are mapped as "Bedrock"

9 not marked as sinks though they are mapped as "Lakes"

39 marked as the highest member in the cascade though they are mapped as "Talus Slope"

While the latter problem is due to the missing of mapped rock walls, other problems may only be solved introducing **semantical based queries** like,

"can Bedrock serve as a sink at all",

"if the landform is mapped as a lake it is always a sink" or

"does two landforms identified as interact in terms of processes acting on these landforms".

We state here, that simple geometrical based algorithms on geomorphological maps have to include semantical queries to determine a more reasonable result.

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