Mapping sediment transfer processes using GIS applications

David Theler
PhD thesis project

6th ICA Mountain Cartography - Lenk 11th-15th February 2008 workshop
Mapping sediment transfer processes using GIS applications

- Why studying sediment transfer processes?
- Geomorphological maps
- Study site
- GIS applications
- Example
- Conclusions
Why studying sediment transfer processes?
Increase of vulnerability X intense meteorological events
= increase of risks

August 2005, flood and debris flows provoked economic losses of 2 billion euros
Geomorphological hazards as Bedload transport & Debris flows are still partly ignored

Parameters acting on debris flow triggering are complex:

- **Meteorology** (intensity and duration of rainfalls, snow cover,…)
- **Topography** (slopes > 15°, altitude, freeze-thaw cycles,…)
- **Geomorphology** (sediment supply zones, sediment thickness,…)
- **Hydrology** (structure hydrography, underground water, glacier,…)
- **Permafrost**
- **Geology** (faults, lithology,…)

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A better mapping recognition of torrential systems, based on geomorphological mapping may improve knowledge of the phenomena
Some geomorphological maps
Geomorphological Maps

- Few maps on geomorphological hazards
- Few maps on morphodynamics
- Sediment transfer study at big scales (1: 10000 – 1: 5000)
- Increase difficulty to distinguish erosion / accumulation landforms that often superposed
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- Few maps on morphodynamics
- Sediment transfer study at big scales (1: 10000 – 1: 5000)
- Increase difficulty to distinguish erosion / accumulation landforms that often superposed
- Considering the system as different sediment storages emptying each other
- GIS applications
Study site
Bruchi

Brig

Blatten

Rhône River

Brig
Geomorphologic context

- Occurrence of debris flows
- Between 1905 and 1907 & Four events after 1987
- Dendrogeomorphological studies (> 400 spruces)
- 11 past active channels
Typical torrential system (1)

Channel

Drainage basin

Massa gorges

Drainage basin

Alluvial fan
Several types of sediment stores in the gullying zone

- Alluvial Deposits (natural levees)
- Landslide
- Rockfalls in folded and fractured rocks
GIS applications
Hillshading

SWISSTOPO has two types of DEM based on very high accuracy laser measures (“MNS” and “MNT-MO”).

The precision of these models is about ± 150 cm for the first one ± 50 cm for the second one with, for both of them, a density of points of 1/m²

The Hillshade function obtains the hypothetical illumination of a surface by determining illumination values for each cell in a raster.

- more precision
- delineation accumulation landforms
- structural landforms hidden by vegetation
Hillshading and geomorphologic features

Alluvial deposits/bedrock & (debris flow lobes)  Tardiglacial Morainic ridge  Erosional escarpment
Hillshading / topographic maps

1: 25000 (2007)

1: 100000 (1982)
Simulating hydrographic network (1)
"Flow Accumulation"

Generation of several raster layers including the **Flow Accumulation** that calculates the accumulated flow at a point.

As the accumulated weight of each cell is based on the flow coming from the upper related cells, this phase is based on the "Flow Direction raster map".
Simulating hydrographic network (2) "Watershed"

“Watershed” tool allows to determine areas that drain water (and other substances like sediments) to a common outlet as concentrated drainage.

By displaying Flow Accumulation raster, it’s easy to create exits of the future sub-basins.
Simulating hydrographic network (2)
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Mapping Sediment storage
**Development of two Matrix**

- After watersheds, delineation of homogenous areas

- Based on Hazard mapping

- **Vegetation** and **slopes** are derived from analysis on DEM

- **Colours** differentiating morphogenesis (green-alluvial deposits, pink-periglacial deposits...)

![Diagram](image)

**Table 1:**

<table>
<thead>
<tr>
<th>Slopes</th>
<th>Vegetation landcover</th>
<th>Physical characteristics derived from DEM</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt; 15°</td>
<td>&lt; 30%</td>
<td>High</td>
</tr>
<tr>
<td>15 &lt; S &lt; 30°</td>
<td>30 &lt; V &lt; 70%</td>
<td>Latent</td>
</tr>
<tr>
<td>&gt; 30°</td>
<td>&gt; 70%</td>
<td>Inactive / fossil</td>
</tr>
</tbody>
</table>

![Diagram](image)

**Table 2:**

<table>
<thead>
<tr>
<th>Sediment storage</th>
<th>Intensity of the process(es) acting on sediment storage</th>
</tr>
</thead>
<tbody>
<tr>
<td>High</td>
<td>High</td>
</tr>
<tr>
<td>Latent</td>
<td>Latent</td>
</tr>
<tr>
<td>Medium</td>
<td>Medium</td>
</tr>
<tr>
<td>Low</td>
<td>Low</td>
</tr>
</tbody>
</table>

![Diagram](image)
Example
Field measurements (1) – Reference colour lines
Watershed # 1
Conclusions
Perspectives: There’s still a lot of work…

- Gravitational processes (not always the same exit as debris flow)
- Transitory deposits
- Estimation of potential delivery sediment volumes
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- Interfluves
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- Gravitational processes (not always the same exit as debris flow)
- Transitory deposits
- Estimation of potential delivery sediment volumes
- Interfluves
- Finally, measurements of monitoring stations (photogrammetry / hydrology)
Thank you for your attention

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