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Modeling of sediment flux at short, middle and long time scale in alpine torrents

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Sediments management has become an important issue in the alpine regions since all deposits of material must be removed from sediment traps to keep their efficiency. However, this is not sustainable to evacuate those deposits over long distances. The goals of this work is to quantify the sediment supply of alpine torrents and active gullies in order to make suatinable management over the long term. From a case study situated in the region of Zinal, Valais, Switzerland, we will try to give general recommendation.

Several approaches are tested to create a model able to estimate the sediment budget at short, middle and long time scale. After a general analysis of the catchment rendering a geomorphological map (process and location), a quantitative assessment of sediment production is performed. Besides, a qualitative representation of sediment transport processes is created that enable the modelling of sediment cascade.

Several new methods are tested combining field work and remote sensing data (DEM, Lidar acquisition and aerial photos). The torrent activity (maximum erosion volume) is estimated with the Slope Local Base Level (SLBL) constrained with field observations (e.g. presence of outcrop). Downstream and cross-sectional topographic profiles along the streams enable to determine their overall dynamics. The model is then composed of homogeneous sections of the torrent. Erosion rates are defined according to the activity observed on time series of aerial photos, historical data, etc. The climate forcing is also considered for assessing torrential dynamics in the prospective sediment balances.

The preliminary conclusion is that 6 sets of information implemented in the model enable estimating the quantity of sediments transport by the torrents ((1) the geomorphologic map, (2) the division of the torrent in homogeneous sections, (3) the longitudinal profile of the torrent, (4) the calculation of the maximum volume mobilized by the torrent (with the SLBL), (5) the estimation of the overall dynamics of the torrent (erosion and deposition areas), (6) the estimation of erosion rate.).

The results obtained using the SLBL allowed us to force the maximum erosion of the stream bed to avoid too extreme values. An advantage of this method is the use of the three dimensions for each meter of the torrent, which is not possible with traditional methods such as calculating by sections of torrent. Then, we find that the dynamic of the torrents (erosion, deposition) is strongly correlated with the level difference between the theoretical profile and the topographic profile along the streams. This characteristic also permits to quantify the total amount of solid material that can potentially be filled by section of stream. In order to determine the proportion of sediment deposited by section (as % of the total volume transported), this result is coupled to an deposition index (slope, width and Epot of the section torrent).

This approach provides, compared to the average value of erosion at a regional level commonly used, a local estimation of the sediments transport for each streams analysed. Indeed, a modelling of sediment cascade allows knowing the amount of sediment transported and especially to know when these amounts could cause problems in their management. It will be useful for different project of sediment management like in-situ storage.