Geophysical Research Abstracts
Vol. 14, EGU2012-11005, 2012
EGU General Assembly 2012

Different approaches to assess the volume of debris-flows deposits: are results comparable?

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Debris-flow hazard planning is heavily dependent on the sediment-volume estimation along with its expected frequency. The reliable determination of this variable allows debris-flow simulation and derives from several methods: statistical elaboration of maximum rainfall/runoff/sediment volumes series, empirical approaches based on catchment morphology, and field surveys on the potential sediment availability. The historical series analysis should be one of the best solution to assess debris-flow magnitude and frequency, especially for unlimited sediment supply basins. Nevertheless this task is difficult due to the lack or non homogeneity of data. Over last decades some Alpine catchments authorities have initiated to systematically record the event features by means of post-event measures, but there is not yet a definitive standard method. An analysis on the variable estimation of volumes of debris-flow deposits volume is here presented.
Study area is located in Italian Central Alps and deals with three neighboring small catchments (<5 square kilometers) characterized by unaltered and almost natural fans at the left side of the Sarca river of 'Val Genova' (Trentino Region, Italy). The investigated catchments, Dosson, Cercen and Gabbiolo, have an unlimited sediment supply which causes granular debris flows made of granitic cobbles and boulders in a sandy matrix. Five recent debris flows events have been studied: two occurred on the 11th of July 2010 and on the 20th of September 1999 in the Dosson torrent, one occurred on the 24th-25th of August 1987 in the Cercen torrent, and two on the 25th of September 2006 and on the 20th of September 1999 in the Gabbiolo torrent.
The integration of digital terrain model analysis, information about soil geomorphology and forestry cover, and field observations has allowed mapping the debris-flow deposits. Furthermore, data about deposit thicknesses and angles of deposition at the fan surface were measured. Thanks to these data some methods have been tested to estimate the volume of debris-flow deposits: a) interpolation of the deposit depths over depositional area via the ArcView tool "Topo to Raster"; (b) simple multiplication of the mean deposit thickness by the depositional area; (c) estimation of a multi-parametric linear regression to compute the deposit depth as function of deposit slope and distance from the fan apex; (d) use of an empirical relation depending on the planimetric area of the deposit raised to an exponent, equal to 2/3, and on a dimensionless mobility coefficient derived from adaptation of literature data; (e) previous method but with the exponent calculated as function of the fan and channel slope; (f) hydrological-hydraulic approach which transforms the reconstructed flow hydrograph into a debris-graph.
Results show a large variability about volumes estimation, but some important key points emerge. The hydrological approach appears weak, being strongly dependent on rainfall data quality and on basin activity before the event. Geomorphic/field-survey-based approaches are more concordant and consistent. Even if the spatial interpolation of deposit thicknesses is over-simplified, such methods results the best alternative to the empirical formulas.