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Preliminary analysis of relevant parameters for debris-flow entrainment using field data and two different numerical codes in the Eastern Pyrenees.

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The basal incorporation of material - also called “entrainment” - is a common characteristic of debris flow dynamics. Even though, it’s a very difficult task to correctly introduce this effect into debris-flow simulation models. In addition, detailed field measurements on erosion rates are still scarce, although such data are fundamental in order to verify and calibrate the proposed entrainment approaches.
Initially, comprehensive field surveys were carried out in 4 catchments affected by debris-flow events in different areas in the Eastern Pyrenees: Sant Nicolau (2008), Port Ainé (2008), Riu Runer (2008) and Ensija (2006). The data measured include entrainment and accumulation rate along the flow path divided into reaches. Additionally, the flow area and flow velocity (using superelevation method and empirical expressions) were determined at different points.
Then, simulations on the dynamic behaviour were performed applying two different numerical codes: DAN and GITS-1D. Both are 1-dimensional (1D), monophasic models using Lagrangian finite difference solution and offer the possibility to define the flow width. The entrainment is incorporated by different approaches. DAN permits to increase the volume by a predefined constant entrainment rate, while GITS-1D incorporates a dynamic function for the basal erosion.
On one hand, the field data were analysed comparing erosion rate with bed slope, peak discharge and type of channel bed material. Preliminary relations were established locally (at measured cross sections) and by reaches, and they were compared with existing data. On the other hand, all the debris-flows were back-analysed by the two numerical codes in order to obtain the maximum flow velocity at each point along the flow trajectory. Thus, entrainment rate could also be related to velocity and peak discharge values, which were numerically calculated.
First results obtained from the field data support the conclusions of previous works (e.g. Hungr et al. 2005) that entrainment is a very complex process depending on multiple parameters. The scatter of the data makes it impossible to establish well defined empirical relationships. However, crude trends can be seen in relation to the effect of channel bed slope and peak discharge. They point out an increase of entrainment in steeper slopes, specially if an considerable colluvium layer is available. It can also be seen that in flows of greater peak discharge the entrainment ratios are higher.
Results obtained by the numerical simulations of the four events using different entrainment approaches indicate that DAN can be perfectly applied for back-analyses, when post-event data of the erosion rate are available. Forward prediction, however, is more difficult since entrainment is a pre-defined variable and must be estimated by field observations. In contrast, the entrainment rate in GITS-1D strongly depends on the friction angle of the bed material and the erosion volume is very sensitive even for small changes of this parameter.

References:
Hungr, O., McDougall, S., Bovis, M., 2005. Entrainment of material by debris flow. In: Jakob, M., Hungr, O. (Eds.), Debris-flow Hazards and Related Phenomena. Springer, Berlin, pp. 135-158.