Peak discharge estimation of the 1997 hyperconcentrated flow event at Arroyo Cabrera (Central Spain)

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The Arroyo Cabrera is a mountain torrent where, on 17 December 1997, an extraordinary and rare hyperconcentrated flow took place. This watershed has an area of 15.75 km2 and it is particularly steep in its headwaters, where the slopes reach values of 30º on average. It is located on the northern slopes of the Gredos mountain range in the Spanish Central System. In this study, we evaluate flood discharge by modelling peak discharge using palaeoflood reconstructions based on high-water marks and, alternatively, with the critical-depth method and empirical equations. A comparative analysis of the results of both methods was conducted. High-water marks consisted of sigmoid erosion marks left in the bed rock at a location where there is an abrupt steepening in slope that causes flow to change from subcritical to supercritical flow by this event. The critical-depth method was implemented assuming as critical-depth the known flow-surface defined by the high-water mark. The cross section where the critical flow condition occurred was established by iteratively determining the cross-section so that the specific energy is minimized. This method has been profusely used in the past to simulate flood events in mountain basins where the occurrence of floods with a high sediment load is frequent. However, the use of this approach could entail an overestimation of peak discharges due to two reasons: a) the method must be used to simulate flows with a Newtonian rheology; and b) sediment load may raise the outstandingly wetted perimeter of a given critical section. On account of these sources of uncertainty, empirical relationships based on hyperconcentrated flow volume as well as flow velocity have also been used to estimate the peak discharge.

Keywords: Mountain torrent; hyperconcentrated flow; palaeoflood; peak discharge; critical flow; Spanish Central System