



Back analysis numerical modelling of the 19/06/1996 Cardoso (Stazzema, LU - Italy) flood: from gravitational movements to their evolution in rapid flows

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During the June 19th of 1996 a storm involved the Tyrrhenian sector of northern Tuscany (Italy), especially hitting the Versilia and Garfagnana areas. Major consequences and damages, due to the extremely intense precipitation (about 500 mm/13 h and 158 mm/h peak intensity), occurred in the surrounding of the Cardoso village (Versilia river basin, Stazzema, LU), with 14 casualties. At 1.20 p.m., the rainfall peak intensity coupled with the development of a large number of shallow landslides, triggered rapid flows and caused severe flooding in the Cardoso area, which was covered by hundred thousand of cubic meters of deposits.

The aim of this study was the characterization of the rapid flows occurred during the event and their back analysis numerical modelling by using a hydrological-hydraulic software. First of all, the amount of mobilized solid volume was assessed, differentiating between materials collapsed from the slopes and those eroded from the low-order drainage network. This goal was obtained by visual interpretation of post-event orthophotos and by morphometric analysis. Subsequently, starting from the rainfall data of the event, the hydrological modelling was performed by the Curve Number method, in order to define flood hydrographs along the drainage network of the Cardoso sub-basins. For the hydraulic modelling, the liquid discharge data were used to calculate debris-graphs of rapid flows, by implementing empirical correlations based on peak discharge, debris volume and channel slope. Different rheological parameters were tested to perform numerical modelling.

Back analysis results allow to infer that the mass movements initially started as hyperconcentrated flows in the upper parts of the sub-basins and after evolved into muddy debris flows, which caused flooding of the Cardoso valley. The results are in good agreement with the flooded area extent, as estimated by visual interpretation of both archive photos and aerial orthophotos acquired immediately after the event.