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A LiDAR based analysis of hydraulic hazard mapping

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Mapping hydraulic hazard is a ticklish procedure as it involves technical and socio-economic aspects. On the one hand no dangerous areas should be excluded, on the other hand it is important not to exceed, beyond the necessary, with the surface assigned to some use limitations. The availability of a high resolution topographic survey allows nowadays to face this task with innovative procedures, both in the planning (mapping) and in the map validation phases. The latter is the object of the present work.

It should be stressed that the described procedure is proposed purely as a preliminary analysis based on topography only, and therefore does not intend in any way to replace more sophisticated analysis methods requiring based on hydraulic modelling. The reference elevation model is a combination of the digital terrain model and the digital building model (DTM+DBM). The option of using the standard surface model (DSM) is not viable, as the DSM represents the vegetation canopy as a solid volume. This has the consequence of unrealistically considering the vegetation as a geometric obstacle to water flow. In some cases the topographic model construction requires the identification and digitization of the principal breaklines, such as river banks, ditches and similar natural or artificial structures. The geometrical and topological procedure for the validation of the hydraulic hazard maps is made of two steps. In the first step the whole area is subdivided into fluvial segments, with length chosen as a reasonable trade-off between the need to keep the hydrographical unit as complete as possible, and the need to separate sections of the river bed with significantly different morphology. Each of these segments is made of a single elongated polygon, whose shape can be quite complex, especially for meandering river sections, where the flow direction (i.e. the potential energy gradient associated to the talweg) is often inverted. In the second step the segments are analysed one by one. Therefore, each segment was split into many reaches, so that within any of them the slope of the piezometric line can be approximated to zero. As a consequence, the hydraulic profile (open channel flow) in every reach is assumed horizontal both downslope and on the cross-section. Each reach can be seen as a polygon, delimited laterally by the hazard mapping boundaries and longitudinally by two successive cross sections, usually orthogonal to the talweg line. Simulating the progressive increase of the river stage, with a horizontal piezometric line, allow the definition of the stage-area and stage-volume relationships. Such relationships are obtained exclusively by the geometric information as provided by the high resolution elevation model. The maximum flooded area resulting from the simulation is finally compared to the potentially floodable area described by the hazard maps, to give a flooding index for every reach. Index values lower than 100% show that the mapped hazard area exceeds the maximum floodable area. Very low index values identify spots where there is a significant incongruity between the hazard map and the topography, and where a specific verification is probably needed. The procedure was successfully used for the validation of many hazard maps across Italy.