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# Mapping of flood risk prone areas: a comparison between different models and techniques.

L. Natale(1), G. Petaccia (1), F. Savi (2) , M. Zanotti (1)

1. Hydraulic and Environmental Engineering Department, University of Pavia, Italy (petaccia@unipv.it / Fax +39(0)382-985589)
2. Hydraulic, Transportations and Highways, University of Rome, La Sapienza, Italy

Mapping of flood risk prone areas due to extreme events in natural rivers is of relevant interest in the engineering practice. Usually, this problem is solved by professional engineers simulating the flood wave propagation by means of 1D mathematical model and identifying the flood prone areas as the areas where the ground is lower that the computed water elevation. When a flood wave propagates along mountain reaches, changes from subcritical to supercritical flow, hydraulic surges and formation of control sections occur. These variations of flow regime are mainly due to abrupt changes in channel geometry and the simulation requires mathematical models and numerical solvers able to reproduce discontinuities (shocks) of the free surface.

Aim of this paper is to compare different 1D mathematical models and solvers in order to investigate the differences in the extent of the flooded areas. Two different models are compared: the public domain HEC-RAS code (developed by US Army Corps of Engineers) and ORSA code (developed by the Authors). The models integrate Shallow Water Equations (SWE), written in non conservative form (HEC-RAS) and conservative form (ORSA). HEC-RAS integrates SWE by means of a classical, implicit "box scheme" which is not suitable to simulate transcritical flow. To overcome this problem, a numerical filter, limiting the convective inertia term, is introduced when flow becomes supercritical. ORSA adopts two different finite volumes solvers to integrate SWE: Roe scheme and a modified Lax - Friedrichs scheme.

In this paper the two models are applied to simulate the 200 years return period flood wave propagation along Brembo River, located in Italian Alps. Brembo River is more than 50 km long, characterised by sudden variations of cross section width (reduction

of 10 times in 100 metres) and adverse slopes. Topographic data were available: 274 cross sections bathymetries, obtained from land surveys, and a 10x10 m DEM. Manning roughness coefficients were estimated by means of land use maps and granulometric curves of the sediments constituting the channel bed sampled along the water course.

Both the models are applied considering the cross sections obtained from the river bathymetries (average distance between two sections lower than 200 m), but HEC RAS fails in simulating shocks due to abrupt changes in channel geometry. In order to regularize the river geometry, the cross sections (same number and location) are extracted from DEM.

Computations indicates that flow regime transitions occurs frequently along the river: HEC-RAS does not reproduce these changes of flow regime and becomes unstable. This code gives acceptable results only decreasing the number of flow regime transitions; this is achieved by magnifying Manning resistance coefficients over the correct values. As a consequence the water depths computed by means of HEC-RAS are significantly greater than those computed by ORSA code.

ORSA gives acceptable results using the original bathymetries as well as the cross section extracted from DEM and the results obtained by the two solvers slightly differ in some cross sections, mainly where hydraulic jumps and control sections occur. Results obtained by using the Roe scheme exhibit relevant oscillations on the peak discharge hydrographs.

However the differences in water surface elevations computed with HEC-RAS and ORSA do not affect significantly the extent of flood areas, since mountainous valleys, as the Brembo one, are quite narrow: differences in flooded areas are evident only in floodplains and in some urbanised areas where the bottom of the valley is relatively flat.