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Effect of uncertainty in Digital Surface Models on the boundary of inundated areas

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The planning, design and operation of flood damage reduction works or non-structural measures require the construction of maps that indicate zones to be potentially inundated during floods. Referring to floods due to heavy rainfall, the common procedure for flood mapping consists of the following five computational steps: (1) Frequency analysis of extreme rainfall; (2) construction of design hyetographs for various return periods; (3) construction of the related direct runoff hydrographs; (4) routing of these hydrographs through the hydrographic network; (5) mapping of the inundated area that corresponds to the temporally maximum depth for each location in the flood plain. Steps 3 through 5 require the use of spatial information which can be easily obtained from a Digital Surface Model (DSM). The DSM contains grid-based elevations of the ground or overlying objects that influence the propagation of flood waves.

In this work, the SCS-CN method is used in step 3 in combination with a synthetic Unit Hydrograph based on the SCS dimensionless Unit Hydrograph. In step 4, the full one-dimensional Saint Venant equations for non-uniform unsteady flow on fixed bed are used, which are numerically solved.

The impact of uncertainty in the DSM on the inundated area boundary is investigated. For this the Monte Carlo simulation method is employed to produce a large number of erroneous DSMs through introducing errors in elevation with a standard deviation equal to σ. These DSMs are then used for delineating potentially flooded areas. The standard deviation of the distance (from the riverbed axis) of the boundary of these areas, herein denoted as σ_F, is used as the measure of the resulting uncertainty. The link between σ and σ_F is examined for a spectrum of large return periods (100 to 10000).

A computer experiment was set up based on data from two drainage basins. The first basin is located in East Attica and is drained by a branch of the Erasinos Torrent named the South-East Kalyvia Torrent; it extends over an area of about 17 square kilometres. The second basin is that of the Kerynitis River in north-western Peloponnesus; it covers an area of 89 square kilometres. In each one of the two basins hydrographs at the outlet of the upper part of the basin are estimated with the aid of hydrological modelling, while, for the lower part hydraulic routing is employed. The South-East Kalyvia basin is hilly, whereas the Kerynitis Basin shows high ground slopes in its upper part and low slopes in the lower part.

Graphs of σ vs. σ_F and maps showing the mean position μ_F of the boundary of flooded area along with limits of this boundary that reflect positions $\mu_F \pm 2\sigma_F$ help visualize the impact of the uncertainty in DSM. To acquire a better feeling of the effect of DSM uncertainty, results are compared to those obtained from uncertain rainfall depths of the design hyetographs.