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River discharge estimation using water section hydrographs and 1D shallow water modeling

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A new procedure is proposed to estimate river discharge hydrograph during flood, using only water level data measured in two gauged sections, as well as 1D shallow water modelling. During flood, the piezometric level is constant in the vertical plane of the two river sites, where the top of the banks is always above the river level, and is well represented by the recorded stage hydrograph. The river is modelled along the reach located between the upstream gauged section, where discharge hydrograph is sought after, and the end section located downstream the second gauged section. The distance between the second gauged section and the end of the modelled reach is about one half the distance between the two gauged sites.
A diffusive model is adopted for flow routing. The motivation of this choice are the model stability with respect to the topographic error, as well as the simplicity of the data required to satisfy the boundary conditions. Assigned boundary conditions are: 1) the recorded stage hydrograph at the upstream station and 2) the zero diffusion condition at the downstream section of the model. This second boundary condition represents an approximation of reality.
The reach length is chosen large enough in order to make negligible the effect of the downstream boundary condition approximation and to well estimate the time lag between the two measured water sections hydrographs. The roughness Manning coefficient is computed as a model parameter, in order to match the measured time lag between the peak water sections in the two measurement stations with the computed one.
The MAST algorithm is used for the numerical solution of the flow routing problem, that is embedded in the Brent algorithm used for the computation of the optimum Manning coefficient. The proposed methodology differs from similar ones previously presented, because it uses the flow area hydrographs instead of the water stage ones for calibration. This is shown to strongly improve the stability of the results. Several historical events, occurring in the reach between Pierantonio and Ponte Felcino gauged sections, located along the Upper Tiber River, have been used for validation. The corresponding benchmark discharge hydrographs had been estimated using either direct velocity measurements or a rating curve previously obtained during events of similar intensity. The optimal Manning roughness coefficient is computed for each event, using no other information from the other available sets of historical data. The proposed discharge estimation method has been able to estimate accurate discharge hydrographs for all analysed events with error in peak discharge less than 4 %.