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GIS Methodology for determination of the flash flood hydrograph in small scale mountainous catchments

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The application of a model for estimation of the flash flood hydrographs in small mountainous catchments is presented. The model is an implementation of a workflow that combines several well known hydrologic methods in a GIS environment to obtain an estimated flash flood hydrograph in a point when the terrain and storm characteristics are known. The model is automated, and only requires the input of some parameters related to the precipitation and spatially distributed terrain data like land use, soil and antecedent soil moisture. The result is the estimated flash flood hydrograph at the catchment outlet. Other intermediate results include the spatially distributed runoff depth, runoff coefficient and travel time to the catchment outlet.

The main reason for using this model instead of other already available models is the dimension of the catchments where the model will be applied. Most models are developed for larger catchments where streams contribute highly to the discharge. In small mountainous catchments surface runoff, rather than streamflow plays a major role in discharge generation. The model consists of four components that calculate: the spatially distributed runoff depth and runoff coefficient; linear runoff routing according to the flow velocity; the discharge and the interpolation of the discharge values to obtain a hydrograph. The first three spatially distributed components of the model were built using ArcGIS Model Builder and the last calculation and interpolation of discharge values was built as a script in MATLAB. The runoff depth is calculated using the hydrologic soil group, land use, and soil hydrologic condition rasters by the SCS-CN method. The runoff coefficient is calculated as the ratio of runoff depth to the total precipitation. The travel time to the catchment outlet is obtained using a flow velocity raster and a DEM and by summing the travel time for each cell downstream until the outlet. Linear runoff routing according to this travel time and flow direction was chosen because these small catchments usually have short stream lengths and hydraulic methods would make the model too difficult to apply with available data. The discharge generated in each raster cell is calculated using the rational method and summed according to the travel time at the catchment outlet. The result is a table of discharge values estimated at a fixed interval until the concentration time is reached. A hydrograph is then generated in MATLAB by interpolating the discharge values and plotting the result. This hydrograph can be interpreted and used as a warning tool for flash flood for a predicted rainfall as an input.

The model is applied to the Căpuş catchment, which is part of the lower Apuseni mountains in the Northwest of Romania. Its altitude ranges from 459 to 1017 m. Three subcatchments comprising 17.2, 57.8 and 103 km^2 were selected in this area. The validation of the results was not possible for all catchments because of the lack of gauges in the area. The value of the maximum discharge in the largest subcatchment is in the range of measured discharges in similarly sized and nearby gauged catchments.