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An integrated system for hydrological analysis of flood events

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The significant increase of extreme flood events during recent decades has led to an urgent social and economic demand for improve prediction and sustainable prevention. Remedial actions require accurate estimation of the spatiotemporal variability of runoff volume and local peaks, which can be analyzed through integrated simulation tools. Despite the fact that such advanced modeling systems allow the investigation of the dynamics controlling the behavior of those complex processes they can also be used as early warning systems. Moreover, simulation is assuming as the appropriate method to derive quantitative estimates of various atmospheric and hydrologic parameters especially in cases of absence reliable and accurate measurements of precipitation and flow rates. Such sophisticated techniques enable the flood risk assessment and improve the decision-making support on protection actions.

This study presents an integrated system for the simulation of the essential atmospheric and soil parameters in the context of hydrological flood modeling. The system is consisted of two main cores: a numerical weather prediction model coupled with a geographical information system for the accurate simulation of groundwater advection and rainfall runoff estimation. Synoptic and mesoscale atmospheric motions are simulated with a non-hydrostatic limited area model on a very high resolution domain of integration. The model includes advanced schemes for the microphysics and the surface layer physics description as well as the longwave and sortwave radiation budget estimation. It is also fully coupled with a land-surface model in order to resolve the surface heat fluxes and the simulation of the air-land energy exchange processes. Detailed atmospheric and soil parameters derived from the atmospheric model are used as input data for the GIS-based runoff modeling. Geographical information system (GIS) technology is used for further hydrological analysis and estimation of direct hydrographs and maximum discharges at specific locations of a drainage basin. For this purpose, a spatial database was designed and implemented. This geodatabase consists of the primary GIS layers such as contour lines, elevation points, stream network, land cover, geological formations and gridded precipitation data. The outputs of the meteorological model (spatiotemporal variation of the excess rainfall and surface runoff) are integrated in the GIS spatial database and a routing function (based on flow direction algorithm) is defined for each cell of the digital elevation model (DEM) in order to determine water flow from cell to cell. All these derived secondary GIS layers are used to calculate the travel-time to outlet maps and the isochrone maps corresponding to the real rainfall event. For the estimation of the maximum discharge at specific defined outlets the GIS based unit hydrograph derivation method is also adopted.

An early version of the system has been implemented in a case study of severe flood in a complex catchment providing detailed and accurate estimation of surface runoff and maximum discharges over the affected areas.