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Combining regional rainfall frequency analysis and rainfall-runoff modelling to derive frequency distributions of peak flows at regional scale: a proposal for Sicily

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Derivation of frequency distributions of peak flows is extremely important for many practical applications in engineering, such as: designing hydraulic structures, water resources planning and management, flood risk assessment and floodplain management. Hydrologic modelling in ungauged basins consists in indirect methods based on simplified description of flood formation process.
At the beginning of the '90s the Italian National Research Group for the Prevention of Hydro-Geological Disaster (GNDCI), developed uniform procedures to estimate intense rainfall and peak flood in Italian country, under the so-called VAPI project. With respect to Sicily region, in spite of some researchers' effort to update the VAPI study, currently there is no consensus on a single standard procedure.
In the present study an attempt is made to provide a general Monte Carlo approach which can be applied to ungauged basins for deriving the corresponding flood frequency curves (i.e. relationship between flood quantiles and related return periods). The proposed procedure is based on a combination of statistical methods for deriving the design storms and simulation techniques, through a rainfall-runoff model, to generate synthetic hydrographs. In particular, a regional analysis of extreme rainfall, namely an index flood-type method, is carried out to derive total storm depths of different return periods. The latter are then distributed in time according to synthetic hyetographs generated by the "Huff curves" method, which provides a probabilistic representation of accumulated storm depths for corresponding accumulated storm durations expressed in dimensionless form.
Estimation of effective storm depths is made through the Soil Conservation Service-Curve Number (SCS-CN) method implemented by considering the Antecedent Moisture Conditions (AMC) as a random variable with a discrete probability distribution, in order to relax the iso-frequency assumption between the design storms and the resulting hydrographs. Finally, a rainfall-runoff analysis built upon the Time-Area (TA) concept is used as flood routing technique. Implementation of the TA technique is based on GIS software to extract topographic data essential for hydrologic modelling from available Digital Elevation Model (DEM)
The proposed methodology is validated on several gauged basins in Sicily region, where synthetic flood frequency curves, obtained by simulating 1000 flood events, are compared to observed values. The results of the application reveal that the Monte Carlo approach is suitable to reproduce with reasonable accuracy the hydrologic response of the investigated basins. Given its relative simplicity, the developed procedure can be easily extended to poorly gauged or ungauged basins to setup a regional procedure for the evaluation of peak discharges