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Frequency analysis of hydrological extremes in Tuscany (Italy)

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Extreme values analyses are usually applied in environmental studies to identify protection systems against the effects of extreme events of environmental processes. A common problem is to assess the return period of rare geophysical occurrences, such as floods or precipitation events, for a site or a group of sites, as they play a relevant role for many water management issues. Due to the variability inherent in a random sample of hydrologic data, many hydrologic frequency studies of extreme values are carried out on a regional basis. Over a territory of about 23000 km2, in Tuscany region, located in central Italy, the time series of annual rainfall maxima of different durations and time series of annual discharge maxima, in the period from 1923 to 2008, are investigated. Particularly, the analysis is carried out on the time series of daily rainfall maxima and annual rainfall maxima of five different durations (1, 3, 6, 12, and 24 hours), of about 600 rain gauges. In the same period, also the discharge data, recorded in several rivers in Tuscany, are investigated. More than 300 gauge stations compose the whole hydrometric dataset, but only 75 have discharge data useful for the analysis. A review of previous works, where subdivisions into zones and sub zones of the Tuscany Region were defined, and the first and second level of a regional hierarchical procedure based on the Two Component Extreme Value (TCEV) distribution were developed, is briefly discussed here. While the third level of the regional hierarchical procedure of the different annual hydrological maxima above is revisited and procedures of uncertainty measurements are proposed. In order to analyse the spatial variability of the investigated variables, a multivariate analysis is also proposed, with the aim to model the relationship among the spatial variability of the variables and the territory characteristics. The territory characteristics and some hydrological samples characteristics are used in the developed models. The used variables are extended to ungauged sites using spatial interpolations such as Kriging and IDW methods. The goodness of the developed models, applied to each defined zones, and different hydrological estremes, is verified with a Jackknife procedure to quantitatively asses the sensitivity of its coefficients. Because of the complex nature of the procedure (identifying subregions, finding a subregional distribution function, scaling by index rainfall), a bootstrap procedure is also developed to assess the uncertainty measure. The obtained results are quite satisfying but the need of uncertainty measurements connected to point estimates deserves a deeper analysis. The estimation procedure could be improved considering the penalized spline regression approach. The possibility to apply a non parametric small area estimation is therefore explored.