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Estimation of recession curve of karst spring hydrograph: example of the spring Gradole

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The spring Gradole represents a typical karst spring of the rising type, which is situated in central part of Istria (Croatia). The drainage area is composed mostly of carbonate rocks (limestone) and partly of flysch components (marls and sandstones). The average altitude of the catchment area is approximately 330 m a.s.l. Strong tectonic deformations have made carbonate deposits very permeable, enabling the infiltration of water. The average rainfall is between 1046 and 1120 mm. The catchment area of the spring is estimated to approximately 114 km2. Several studies have shown that the recession curves of karst spring hydrographs characterize the storage properties of karst aquifers. The change in slope can be explained with the drainage of different types of media typical for karst, such as conduits, fractures, pores and fissures. The main factors that affect the recession curve are aquifer lithology and geometry of conduits. Consequently, the recession curve analyzes can provide information about the aquifer and the main features of karst rock massif. Usually, the recession curves can be fitted well by the function that consists of two or more exponential terms with exponential coefficients 1,2,. . . , where the lower coefficient 1 represents the slow flow through porous medium or base flow. The recession curve that represents base flow is usually named as the master recession curve and its exponential coefficient 1 is named as the master recession coefficient. In this study, classical methods for estimation of recession curve are applied to the hydrograph of the spring Gradole. The results are compared with those obtained by applying Composite Transfer Functions (CTF). Differently from classical parametric and nonparametric transfer functions that represent the quick flow and base flow component of spring response by a single function, CTF represents the spring response by two functions adapted for the quick flow and the slow flow component. The quick flow component is represented by a nonparametric transfer function, whereas the slow flow component is represented by a parametric transfer function which is an Instantaneous Unit Hydrograph (IUH) formulated and defined mathematically from a conceptual model. By using CTF for Rainfall-Runoff (RR) modeling, the simulations of long recession periods as well as the simulations of complete hydrograph become more successful. If IUH defined from the conceptual model of linear reservoir is applied, the parametric transfer function representing slow flow component has exponential form. It means that the recession coefficient of IUH represents the master recession coefficient of the spring hydrograph, i.e. the recession coefficient of IUH can be determined by using classical methods for the estimation of master recession coefficient, and vice versa, the problem of determination of master recession coefficient can be transformed to the problem of determination of the recession coefficient of IUH. The recession coefficient of IUH is determined simultaneously with the values of nonparametric transfer function in the optimization procedure for estimation of parameters of RR model based on CTF. The recession coefficients of IUH are obtained separately in the optimization procedures for each hydrological year during the period 1987-2002. The results show that the recession curve of the spring Gradole has not a unique form. Depending on hydrological year, the obtained nonparametric transfer functions representing quick flow component can be fitted by one or two exponential terms. The values of master recession coefficient vary between 100 and 260 days. The average value for the entire period of 15 years is 140 days. These results are similar to the results obtained by applying classical methods for estimation of master recession curve. It confirms practically that the recession coefficient of IUH can be estimated from the spring hydrograph, which can be useful for RR modeling based on CTF because the number of unknown parameters is reduced.