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Copula frequency analyses of peak discharge, hydrograph volume and suspended sediment concentration

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The aim of the study was to carry out frequency analyses of peak discharge, hydrograph volume and suspended sediment concentration series on one station from Slovenia and on five stations from USA with the use of 3-dimensional symmetric and asymmetric copula functions.

Many water resources manager's deals with problem of hydropower reservoir filling and turbine abrasion and proper procedures are needed in order to estimate suspended sediment loads. Furthermore most of the suspended material is transported during few extreme events, which are usually in coincidence with annual maximum peak discharge values and consequently also with corresponding hydrograph volumes. Univariate frequency analyses are mostly performed in hydrology to obtain relationship between design variables and return period. However many hydrological processes are multidimensional and therefore copulas seem to be an interesting option for simultaneous modelling of peak discharges, hydrograph volumes and suspended sediment concentrations.

Stations with watershed areas between 920 km2 and 24996 km2 were used in order to test the proposed procedure of trivariate frequency analyses of peak discharge, hydrograph volume and suspended sediment concentration using copula functions. First baseflow was separated in order to determine hydrograph volumes. Different parametric marginal distribution functions were tested and optimal distributions were selected based on RMSE, MAE model selection criteria, Kolmogorov-Smirnov test and graphical QQ plots. Univariate distribution functions parameters were estimated with the use of method of L-moments, parameters of copulas were estimated with maximum pseudo-likelihood method. Symmetric and asymmetric versions of Gumbel-Hougaard, Frank and Clayton copulas were compared. Statistical (Cramér-von Mises) and graphical tests for copulas were used in order to determine the most appropriate copula function and also primary and secondary return periods were calculated (OR and Kendall's RP). Different dependence structures among three considered variables were modelled with the use of symmetric and asymmetric copulas, where in all cases Gumbel-Hougaard copula was selected as optimal.