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Catchment characterization based on runoff copulas

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The need of a robust approach to perform catchment classification based on similarity measures has increased in the previous decades specially due to the problem of runoff predictions in ungauged basins. A number of similarity measures have been already applied for this purpose in several hydrological studies. All these studies share some common features: e.g. they rely on unsupervised clustering methods in which the distance metric is selected *a priori* and the cluster characterization is based on several criteria, which, in turn, depend on the relationships among a preselected set of predictors. The disadvantage of these approaches is that they may perform well with one runoff characteristic but often perform poorly with those not considered in the sample. Consequently, several classifications may be possible.

In this paper, we propose a general procedure to find simultaneously an adaptive metric and a linear (or non-linear) embedding of the observation space of the predictors using moments derived from runoff pairwise density copulas. Here, these moments are used as proxies of the "system's behavior", whose variance should be minimum for those basins that are "real" neighbors in the embedded space. These statistics provide valuable information for catchment characterization because they are scale invariant and can be regarded as the pure expression of the dependence of the discharge series without the influence of the respective marginal distributions. Moreover, there is strong evidence that dominant processes (e.g. climatic or morphological) are behind the sameness among these copulas.

To illustrate the application of this technique, several catchments in the German states of Banden-Württemberg and Saxony are presented. Each catchment is characterized by a number of morphologic (e.g. area, slope, aspect), climatic, land cover, and runoff characteristics. The climatic and hydrological characteristics we used include: the antecedent precipitation index, the areal precipitation, the spatial variance of the pre-

cipitation, wetness and dryness indexes based on circulation patterns, the change in discharge for a given day, the specific peak discharge, the total drought duration, and the cumulative specific deficit.

The results of this study showed that the quality of the classification using the proposed procedure can be improved substantially compared with standard approaches. Uncertainty and crossvalidation analyzes showed that the proposed technique may be appropriate in the case of ungauged catchments.