# A LOOK AT THE POTENTIAL OF REGIONAL PROCESS-ORIENTED LOOK AT BIVARIATE FLOOD FREQUENCY ANALYSIS FROM THE PERSPECTIVES OF ENGINEERING AND COMPARATIVE HYDROLOGY

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## Abstract

The seasonality of hydrological characteristics is one of the many vital factors controlling the development and stability of natural ecosystems and determining flood and drought hazards. From a hydrological perspective, seasonality analysis of runoff is appealing for inferring flow generation mechanisms. That, in turn, supports engineering hydrological applications, such as hydrological regionalization of extremes and design values, which are crucial inputs for water resources management, engineering design and landscape planning.

In contrast to studies that primarily focus on the statistical aspects of statistical models, we illustrate here, using comparative analysis, the potential of such an approach in bivariate frequency analysis. We aim to analyse the relationships between flood peaks and volumes, explicitly focusing on flood types by the seasonality of flood generation processes. That leads us to study, instead of the usual approach that deals with an analysis of the annual maxima of flood events, to include an analysis of seasonal flood events. That enables us to distinguish the controls on flood generation represented by their duration and flood wave shapes based on the concept of comparative hydrology. Moreover, we can, rather than modelling a single catchment in detail, regionally compare catchments with contrasting characteristics in order to understand the controls holistically and describe the functioning of climatic controls such as storm type (synoptic and convective storms, rain-on-snow, snowmelt) and catchment controls such as soils, soil moisture, geology, and landform.

From the engineering perspective, the following types of flood processes were considered here in more detail: summer/winter floods, synoptic floods, flash floods and snowmelt floods in illustrative examples. In order to increase the sample size and the homogeneity of the samples for the statistical analysis, hydrologically independent flood events can be isolated and assigned to one of the flood process types. To comply with the IID principle, flood events are proposed to be considered independent when they originate from distinguishably different synoptic/meteorological situations and identically distributed according to the regional flood type.

When applying such an analysis, it is helpful to compare empirical copulas regionally first to verify whether the flood processes considered are discernible regarding the corresponding bivariate flood-peak relationships. Next, the types of copulas frequently used in hydrology can be fitted, and their goodness-of-fit examined in a regional scope. The spatial similarity of copulas and their statistical rejection rate, depending on the flood type, region, and sample size, can be examined, too. The methods are demonstrated in pilot studies of selected regions in Austria, Slovakia and the Czech Republic.

Based on our experience, treating flood processes separately in such way is beneficial, both hydrologically and statistically, since experience shows that flood processes and their relationships are discernible locally and regionally in pilot regions. However, the uncertainties inherent in the copula-based bivariate frequency analysis itself (caused, among others, by the relatively small sample sizes for consistent copula model selection, upper tail dependence characterization and reliable predictions) may not be entirely overcome even in the scope of such regional comparative analysis.

**Keywords:** flood types, process-based classification, regional analysis, flood peaks, flood volumes, copula models