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Flood frequency analysis with uncertainty estimation and its application for hazard assessment – a case study in the Mekong Delta

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In many flood-prone regions on earth, the nature of the floods calls for a multivariate approach as analyzing flood frequency, which provides a basic for a sound flood hazard and risk assessment. That is because the flood severity is determined not only by the peak flood discharge as usually considered but also by other aspects such as the volume and even the hydrograph shape of the flood. However, the multivariate flood frequency analysis taking into account its associated uncertainty sources has rarely been studied. The Mekong Delta is one of the largest and most densely populated deltas on Earth. It witnesses annual large scale inundations which are associated to the SE-Asian monsoons. These floods are the basis for the livelihoods of the population of the Delta, but they are also the major hazard. This hazard has, however, not been studied within the frame of a probabilistic flood hazard analysis.

Thus this study focuses on the identification of a suitable statistical model for the estimation of flood frequencies considering two important flood aspects peak Q and volume V and exemplifies its applicability for a sound flood hazard assessment for the case study in the Mekong Delta. A copula-based bivariate statistical model with bootstrapping-based uncertainty estimation is, hence, developed for a flood frequency analysis of peak flow and volume. The analysis reveals that even with the available - in a hydrological context – quite long data series (e.g. 88 years in the Mekong Delta), large uncertainties are associated to the bivariate quantiles (Q, V), even for rather frequent events. The main uncertainty source is the sampling uncertainty, thus a direct consequence of the limited length of the data series. However, we still advocate for applying the proposed bivariate frequency method for flood frequency estimation in the Mekong Delta because a) it reflects the essential aspects of floods in this region, b) the uncertainties are inherent for every multivariate frequency analysis in hydrology due to the general limited length of observations and can hardly be avoided, and c) a framework for the quantification of the uncertainties is given, which can be used in the hazard assessment. The results of the analysis are then used for flood hazard assessment employing the calibrated large-scale hydrodynamic model for the region.