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Joint Distribution and Design of Precipitation-Tide and Impact from Sampling in the Coastal City

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Instream flooding in coastal areas often becomes more severe when heavy precipitation and high tide occur simultaneously. Flood modeling under such conditions requires the computation of joint distribution of precipitation and tide. The Xixiang River basin, that locates in the western of Shenzhen City, South China, experiences such flooding. Using data of 24-hour heavy precipitation and the corresponding daily high tidal levels were used to investigate flooding in the Xixiang basin. Two sampling methods, namely, the annual maxima and peaks over threshold, were applied to construct the precipitation and tidal level series. The joint distribution of precipitation and tide was derived using the Archimedean copulas, where their marginals were fitted by five three-parameter probability distributions. Then, the joint return period of precipitation and tide was calculated by the Kendall measure function and further simulated by the Monte Carlo method. Two methods, namely, the equalized frequency method and most-likely weight function, were employed for the joint design precipitation and tide. The differences in the joint distributions of design of precipitation and tide arising from the two between different methods of sampling were investigated. Results showed that for sampling by peaks over threshold heavy precipitation 6.87 times the annual mean coincided with more and greater high tidal level. The generalized normal distribution was found to fit the marginal distributions of precipitation and tide well, but the location, scale and shape parameters for the two sampling methods differed markedly for heavy precipitation and slightly for high tidal level. Heavy precipitation had a significantly left-skewed distribution but the high tidal level followed almost the normal distribution. Though the dependence of heavy precipitation and high tidal level was quite small and positive, Archimedean copulas effectively modeled the joint distribution of precipitation and tide and the Gumbel-Hougaard copula yielded the optimal joint distribution. Based on the equalized frequency method, the joint design precipitation and tide for the peaks over threshold sampling was safer than that for the annual maxima sampling. However, for the most-likely weight method design precipitation and tide remarkably tended to the lower heavy precipitation and the higher high tidal level. If the sampling method and the joint distribution were determined, a reciprocal situation for the design pairs of precipitation and tide occurred for a given joint return period, that is, a greater design value of heavy precipitation corresponded to a smaller design value of high tidal level, and vice versa. Therefore, which design method was safer was not determined. In design practice, the hydrodynamic process of instream flooding by different design pairs of precipitation and tide should be further investigated for levee overtopping.