Copula-based risk analysis of agricultural water shortage under natural precipitation supply condition in semiarid regions

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Abstract

Accurate risk forecasting of agricultural water shortage has important meaning for the prevention and reduction of disasters in regional agricultural production. The encounter situation of effective precipitation (Pe) and crop water requirements (ETc) can determine the regional agricultural water shortage risk under natural precipitation supply condition. The Guanzhong Plain (GP), divided into Eastern Guanzhong Plain (EGP) and Western Guanzhong Plain (WGP), is sensitive to water shortage as a result of the local arid and semi-arid climate. Based on the daily meteorological data at six representative weather stations in GP from 1962 to 2016, Pe and ETc, which were marked as Pey, Pew, Pes and ETcy, ETcw, ETcs over a hydrological year, winter wheat growth period and summer maize growth period respectively, were computed and their marginal distributions were examined. Also, the copula functions were employed to model the joint distribution of Pe and ETc. The results indicated that the optimal fitted marginal distributions for Pey, Pew and Pes proved to be Lognormal, GEV and Normal in EGP, respectively, and Gamma, Log-Gamma and Weibull in WGP, respectively. GEV correlated all the ETcy, ETcw and ETcs optimally both in EGP and WGP. The Frank copula was identified as the most suitable model for the joint modelling of Pe and ETc series. According to the joint probability distribution, the asynchronous encounter probability of Pe and ETc was around three or four folds of the synchronous encounter probability in GP. Further, probabilities of the occurrence of slight, moderate, severe, and extreme agricultural water shortage under natural precipitation supply condition were 0.51, 0.20-0.30, 0.04-0.10, 0.01 in EGP, respectively, while the corresponding values were 0.52, 0.20-0.23, 0.03-0.09, 0.01 in WGP, respectively. Overall, GP confronted serious agricultural water shortage, and such incompatibility was more serious in EGP compared with WGP. This study can provide an important guidance for the adjustment of crop planting structure, the establishment of irrigation system and the optimal allocation of regional water resources.

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