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Integrated design method for multivariable hydrometric network based on coupled information entropy and copula theory

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Gathering hydrologic data from hydrometric networks is the first step for water resources and management. Reliable and representative hydrometric data are fundamental and important for the effective management of water resources, which calls for careful evaluation and design of monitoring networks in hydrology and hydrometeorology. Information theory is widely used in the design of monitoring networks because it provides a quantitative measure of the information content within a hydrometric network. The Copula theory offers a flexible way to construct a joint distribution independent from marginal distributions. The main advantage of this approach is that it is free from constraints of different marginal distributions, which is common in different hydrological variables. Due to this property, the application of copulas in bivariate and multivariable hydrological analysis has grown rapidly in the past decade. Here we propose a method for integrated design of multivariable hydrometric networks based on coupled entropy and copula theory. The entropy theory is applied for maximizing information and minimizing redundancy of the monitoring network. Meanwhile, the copula theory is utilized for constructing dependence structure of different monitoring hydrological variables and therefore we can realize an integrated design for multivariable hydrometric networks. We apply the method to the integrated design of a monitoring network in Wei River system, especially for precipitation and streamflow monitoring. Wei River is the largest tributary of the Yellow River. The development and protection of Wei River basin is very important for the whole Yellow River basin. There are many tributaries on both sides of the Wei River, of which 14 tributaries covering a catchment area of more than 1000 km2 for each and mostly concentrated on the north shore of the Wei River. The Wei River basin has a typical continental monsoon climate and is located in the transition zone between arid and humid areas. The average annual precipitation in the basin is about 572 mm, and the precipitation has a great influence on streamflow. So integrated design for precipitation and streamflow monitoring network is important and necessary, which can account for interconnection between hydrological variables in the water cycle. In addition, the integrated hydrological network design can adapt to a wider range of practical needs for decision making, and is also very scarce in the previous studies. The proposed method has great flexibility and can be applied for other hydrological variables and monitoring networks. To conclude, it provides a new perspective and direction for the integrated design of multivariable hydrometric networks.