

ABSTRACT

Kao, Shih-Chieh. Ph.D., Purdue University, May 2008. Multivariate Statistical Analysis of Indiana Hydrologic Data. Major Professor: Rao S. Govindaraju

A multivariate statistical analysis of rainfall and streamflows over Indiana was pursued in this study. Copulas are emerging as a statistical tool that provides a flexible algorithm for constructing joint distributions so that both the structure of marginals and dependence can be faithfully preserved. Three hydrologic applications are presented: (1) probabilistic structure of storm surface runoff, (2) multivariate extreme rainfall frequency analysis, and (3) drought analyses. In the first application, two defining characteristics of rainfall events, average intensity and duration, were selected to construct the probabilistic structure of storms using Gumbel's bivariate exponential distribution. The probabilistic structure of surface runoff using Soil Conservation Service (SCS) rainfall-runoff model was derived under this construct. The results indicate that the dependence between average intensity and duration has a significant effect on statistical properties of rainfall excess. In the second application, extreme rainfall events were analyzed using both bivariate Archimedean copulas and trivariate Plackett copulas. The most appropriate definition for selection of extreme rainfall samples was suggested. Joint distributions of extreme rainfall events were constructed and used to compute design rainfall estimates. Comparisons between the conventional and copula-based rainfall estimates showed that the traditional univariate analysis provides reasonable estimates of rainfall depths for durations greater than 10 hours but fails to capture the peak features of rainfall. In the third application, the potential of copulas in characterizing droughts from multiple variables was explored. A joint deficit index (JDI) was defined by using the distribution function of copulas to provide an objective (probability-based) description of the overall

drought status. Not only is the proposed JDI able to reflect both emerging and prolonged droughts in a timely manner, it also allows a month-by-month drought assessment such that the required amount of precipitation for achieving normal conditions in future can be computed. The results of this study demonstrate the wide applicability of copulas to multivariate hydrologic problems.