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Information theory-based metrics applied to hydrologic time series

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The information theory has been previously used to develop metrics that allowed to characterize temporal patterns in soil moisture dynamics, and to evaluate and to compare performance of soil water flow models. The objective of this study was to apply information content and complexity measures to characterize temporal and spatial variations of streamflow. USDA-ARS experimental watersheds in Georgia and in Vermont were selected as the study sites. Both watersheds comprised several monitored sub-watersheds with more than 30-year continuous data records of precipitation and streamflow. Information content measures were the metric entropy and the mean information gain, and complexity measures were the fluctuation complexity and the effective measure complexity. These measures were computed based on the binary encoding of 5-year daily, half-daily and quarter-daily time series of streamflow and precipitation in the watersheds and sub-watersheds. The empirical probabilities of joint or sequential appearances of the binary symbol sequences were input variables to compute the information content and complexity measures. The information content of streamflow time series was much smaller than the one of precipitation data, and had the higher complexity, indicating that watersheds acted as filters of information brought by precipitation. The large variations in information content and complexity measures of streamflow time series with different time scales indicated the significant temporal-scale effects on the measures of streamflow. Moderate spatial scale effects of spatial resolution on the information content and complexity measures of streamflow time series were observed. The latter effects varied depending on sub-watershed location, size, and land use. The information content and complexity measures can provide useful complementary knowledge about the hydrologic system complexity and patterns of its behavior in space and time.