

Community structure concept for catchment classification: A modularity Density-based edge betweenness (MDEB) method

ABSTRACT

Catchment classification is useful for a variety of purposes in hydrologic, environmental, and ecosystem studies. In the context of classification, the concept of community structure, within the realm of complex networks, is particularly attractive and gaining attention in catchment classification studies. Among the many community structure methods, the edge betweenness (EB) method, which applies a hierarchical clustering concept, is one of the most widely used. The EB method, however, is susceptible to the issue of scale (or size) of the network, essentially due to the modularity function that is used to measure the strength of the community structure. To overcome this limitation, the present study proposes an improvement to the EB method. The proposed method, termed as the Modularity Density-based Edge Betweenness (MDEB) method, uses a modularity density function (or D value) by maximization, to obtain the best split of the network. The effectiveness of the MDEB method is evaluated through its application for catchment classification using streamflow data from two large networks: 218 stations from Australia and 639 stations from the United States (US). For each network, three different scenarios in network sizes are studied: (1) the entire network; (2) smaller network sizes based on 100 random realizations, with each realization having 100 and 300 stations for Australia and the US, respectively; and (3) smaller network sizes based on nine different drainage division regions in Australia and 18 different hydrologic units in the US. The classification outcomes from the MDEB method for these three scenarios are compared with those from the EB method. The results indicate that the MDEB method generally performs better than the EB method, for both Australia and the US. The superiority of the MDEB method is evaluated in terms of the number of communities identified and the number of stations that change communities when different network sizes are considered. The catchment communities are also interpreted in terms of the distance-correlation relationship. The results from the present study offer further evidence as to the usefulness and effectiveness of the community structure concept for catchment classification, especially the proposed MDEB method.