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A generic theory for hydrologic modeling: An approach based on complex networks

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The search for a generic theory for hydrologic systems has been a long-standing endeavor. One of the key requirements for developing a generic theory for hydrologic systems is an adequate knowledge of the connections among the various components at a broad range of spatial and temporal scales. Despite our progress so far through development and application of various scientific approaches and mathematical techniques, our understanding of such connections remains largely inadequate. The present study argues that the science of complex networks serves as a bridge between the top-down approaches and the bottom-up approaches and offers a generic theory for studying all connections associated with hydrologic systems. First, the history of network theory and the basic concepts and measures of complex networks are reviewed. Next, the relevance of complex networks for studying connections in hydrologic systems is explained through several examples, including the hydrologic cycle, rainfall and streamflow monitoring networks, global climate model (GCM) outputs, and river networks. Then, the usefulness of the ideas of complex networks in hydrology is tested through their application to streamflow data monitoring networks in the United States, focusing on spatial variability, interpolation/extrapolation, and catchment classification. Finally, the implications of the outcomes of this analysis for hydrologic modeling and prediction, and for water resources planning and management at the broader scale, are also discussed.