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Complexity, Connectivity, and Scale in Hydroclimatic Systems

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Hydroclimatic systems are complex nonlinear dynamically-evolving systems, often made up of a large number of interconnected components that change both in space and in time. Therefore, any effort towards reliable modeling and forecasting of hydroclimatic systems requires proper selection of scientific concepts and methods. Many different scientific concepts and methods have been proposed in the literature and applied to numerous hydroclimatic systems, processes, and problems around the world. Among such, concepts and methods based on chaos theory, complex networks, and fractal theory have been found to offer unique and useful avenues for studying hydroclimatic systems and, thus, have been finding widespread applications in recent times. The purpose of the present study is to discuss the advances in the applications of these concepts to hydroclimatic systems and to look toward the future. This is done through: (1) presenting some key aspects of chaos theory, complex networks, and fractal theory and their relevance to hydroclimatic systems; (2) reviewing various applications of these concepts to hydroclimatic systems, processes, and problems; (3) addressing important data-related issues in the applications of these concepts to hydroclimatic systems; and (4) offering specific directions to advance these concepts and applications further, especially in the context of future grand challenges associated with hydroclimatic systems.