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Sensitive dependence and chaotic dynamics in runoff process

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There is growing evidence on the presence of chaotic dynamics in runoff process. This is certainly encouraging for runoff modeling and forecasting, as it offers possibilities for simple models and better short-term forecasts, as opposed to complex models and probabilistic forecasts (for both short-term and long-term) that are often the case with the stochastic approaches. Nevertheless, criticisms on chaos studies in runoff (or any other hydrologic) process still continue, citing either the potential limitations of chaos identification methods or the inadequacy of data or both. In the present study, a new idea is proposed for chaos identification in runoff process. The idea has its basis on 'nonlinearity' and 'sensitive dependence,' which are essential characteristics of chaotic systems. A two-step procedure is adopted: (1) generation of many runoff data sets (outputs) corresponding to different rainfall scenarios (inputs), using some widely used rainfall-runoff models (e.g. Tank, SWAT); and (2) identification of the dynamic properties of these runoff data sets, using a variety of analysis tools (e.g. phase-space reconstruction, correlation dimension, close returns plot). River basins in the Korean peninsula are considered as the test basins. The purpose is to show that runoff may exhibit dynamic characteristics that range anywhere from a deterministic extreme to a stochastic extreme when the underlying conditions (e.g. rainfall inputs, basin characteristics) change, even slightly. In light of this, the limits to long-term predictability of runoff and other hydrologic processes, especially in ungaged basins, are highlighted.