Spatiotemporal stochastic open-channel flow. I: Model and its parameter data

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Abstract: Engineering predictions of flows in open-channel systems are fraught with ambiguity due to spatial and temporal variability, measurement error and limited sampling of the parameters that represent system properties, boundary and initial conditions, and sinks/sources. Over recent years, steady progress has been made in addressing this uncertainty and the notions of risk, reliability, and confidence that uncertainty poses to planning, design, and management decisions. A number of simplified approaches have been explored for modeling open-channel flow as a stochastic process. However, for a variety of reasons, none have addressed the complete spatiotemporal random nature of the flow. This paper presents the Saint-Venant model as a set of stochastic partial differential equations whose parameters are spatiotemporal random fields. Alternative solution approaches are discussed and compared based upon a consideration of the structure of the governing equations and the statistical characteristics of the parameters. Analysis of extensive field data provides evidence that model parameters have high relative variability, are statistically nonhomogeneous, and commonly have nonnormal residuals with strong lag-dependent correlation structure. Such characteristics must be accounted for in implementing any proposed method for solution of the full Saint-Venant equations in a stochastic setting. A companion paper uses Monte Carlo simulation to capture these traits in exploring solutions for representative and generalized stream systems.