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Ensemble modeling of the stochastic Saint-Venant equations in one shot under uncertain channel properties

Alain Dib (1) and M. Levent Kavvas (2)

(1) Department of Civil and Environmental Engineering, University of California, Davis, United States (aedib@ucdavis.edu), (2) Department of Civil and Environmental Engineering, University of California, Davis, United States (mlkavvas@ucdavis.edu)

The Saint-Venant open-channel flow process becomes stochastic due to the presence of uncertainties in flow parameters, such as the channel roughness and lateral inflows. A well-known approach to obtain the ensemble behavior and variability of such a process is the Monte Carlo method. The main disadvantage of this approach, however, is its computational expense, which comes as a result of the large number of simulations that are usually performed. To eliminate the need for numerous simulations, this study proposes a new methodology to obtain the expected system behavior and the statistical properties of the flow variables of the Saint-Venant open-channel flow process in only one simulation. The proposed methodology involves describing the stochastic Saint-Venant equations of an open-channel flow problem, with an uncertainty arising from the channel roughness coefficient, by using the stochastic method of characteristics. Then, the nonlocal Lagrangian-Eulerian Fokker-Planck Equation (LEFPE) of the stochastic Saint-Venant equations is developed. The developed deterministic and linear LEFPE, which describes the probability density function of the state variables of the system in both time and space, is then solved in a single simulation to provide the ensemble behavior and variability of the open-channel flow problem. The results of the new methodology are validated against the statistical properties calculated by the Monte Carlo method over the same open-channel flow problem. The validation reveals that the proposed methodology can adequately express the ensemble behavior of the Saint-Venant open-channel flow process under uncertain channel properties.