Relative Entropy-Based Global Sensitivity Analysis in a Complex 1D-2D Coupled Hydrodynamic Flood Modeling System

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Abstract

Hydrodynamic flood modeling is computationally complex and data-intensive. The accuracy of the flood model outputs is extremely sensitive towards the quality of input parameters. These input parameters are static (mostly geomorphic) and dynamic (mostly hydrometeorological). Sensitivity analysis helps to identify the importance of each input and subsequently improves model accuracy. In various past studies, the sensitivity of only dynamic input parameters was highlighted. Moreover, the sensitivity analysis was limited to flooding of the channel (1D) or floodplain (2D) but never coupled. The present study focuses on developing a framework for global sensitivity analysis of static input parameters in a 1D-2D coupled hydrodynamic flood model, based on HEC-RAS, an open-source flood modeler developed by the U.S. Army Corps of Engineers. A set of numerical experiments was conducted in the model by perturbing the static input parameters from their standard or surveyed values to generate flow hydrographs. The Kullback-Leibler entropy was used as a metric to quantify sensitivity and was calculated by comparing non-parametric probability density functions (PDFs) of the river discharge at different locations. A Gaussian kernel PDF is found most appropriate in a goodness of fit test than other distributions. A highly flood-prone and densely populated river catchment of the Ganges basin in India, which suffers economic and life losses every monsoon, was selected to demonstrate the proposed framework. This study is the first attempt at a global sensitivity analysis in a 1D-2D coupled flood modeling system, concluding that the sensitivity of static input parameters is highly dynamic, and their importance varies spatially from u/s to d/s of the river. However, the channel roughness and land use classes were found significantly sensitive throughout the river. It is suggested that a flood modeling exercise should accompany a global sensitivity analysis, which will guide flood modelers to identify the sensitive input parameters that one should emphasize during data collection and application. Such effort ensures improved accuracy of the static input parameters resulting in better accuracy of the outputs. The proposed framework is generic and can be implemented for any river catchment prior to flood hazard and risk analyses.

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Keywords: Hydrodynamic flood model, Kullback-Leibler entropy, Gaussian kernel, India, HEC-RAS, global sensitivity analysis.