

ABSTRACT

Jung, Younghun. Ph.D., Purdue University, August 2011. Uncertainty in Flood Inundation Mapping. Major Professor: Venkatesh M. Merwade

In the last decade, flood inundation maps have been an important tool in strategic decision-making to minimize losses from flooding. Generally, flood risk management is based on the prediction of flood inundation for the designed flood events (e.g., 100 years) using flood modeling. Flood inundation modeling includes hydraulic modeling, hydrologic modeling, and terrain analysis. The accuracy of flood prediction is associated with the internal and external uncertainties in flood inundation modeling. To address the issue of uncertainty in flood inundation modeling, the objectives of this study are: 1) to estimate the uncertainty propagation from model variables into flood inundation prediction; 2) to quantify the uncertainty in flood inundation mapping using generalized likelihood uncertainty estimation (GLUE) and sensitivity analysis; and 3) to assess the role of prior and posterior PDFs on subjectivities in uncertainty quantification using the GLUE methodology. Three variables, namely, discharge, topography, and Manning's n are used for uncertainty analysis in this study. The objectives of this study are accomplished by using a 1D HEC-RAS model and data from study areas including the East Fork White River near Seymour, Indiana (Seymour reach) and the Strouds creek in Orange County, North Carolina (Strouds reach).

The first order approximation is used for estimation of the propagated uncertainty rate from a single variable with two other fixed variables, and Hornberger-Spear-Young (HSY) method is applied to the evaluation of relative sensitivity between two model variables with a fixed variable. Estimation of uncertainty propagation using the FOA method shows that the uncertainty of a single variable is propagated differently to the flood inundation area, depending on the role of other variables in the overall process. In addition, the results from HSY sensitivity analysis show that topography is a major contributor on the uncertainty of the flood inundation area at the Seymour reach, and discharge is the major contributor at Strouds reach.

Performance of GLUE is assessed by selecting three likelihood functions including the sum of absolute error (SAE) in water surface elevation and inundation width, sum of squared error (SSE) in water surface elevation and inundation width, and a statistic (F-statistic) based on the area of observed and simulated flood inundation map. Results show that the uncertainty in topography, roughness and

flow information created an uncertainty bound in the inundation area that ranged from 1.4 to 4.6 % for Seymour reach and 4 to 29 % for Strouds creek of the base inundation areas. Additionally, flood inundation maps produced by applying GLUE have different uncertainty bounds depending on the selection of the likelihood functions. However, the overall difference in the flood inundation maps based on different likelihood functions is less than 2 %, thus suggesting that the subjectivity involved in selecting the likelihood measure in GLUE did not create significant impact on the overall uncertainty quantification in flood inundation mapping of the selected study areas.

The prior and posterior PDFs for model variables are used to find an appropriate likelihood measure and cut-off threshold in quantifying the uncertainty in the flood inundation using GLUE. Likelihood measures considering differences of water surface elevations at cross-sections (E), flood extent at cross-sections (W), and flood boundary extent (F) between observation and simulation are used. The prior PDF for either of model variables is assumed as a normal or uniform distribution. The results illustrate that effective ranges can be determined by manipulating thresholds and likelihood measures based on the prior and posterior PDFs of the model variables. Uncertainty bounds based on the E likelihood measure is least affected by prior PDFs of the model variables for the Seymour reach. In addition, the uncertainty bound from an effective range of the model variables shows reductions of 29 to 40% for the uncertainty bounds using the initial ranges.