

# **Evaluating uncertainty in FEMA Flood Insurance Rate Maps (FIRMs) using Bayesian model averaging (BMA) and hierarchical BMA**

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December 2021



# Are FIRMs really firm?

- Flood insurance rate maps (FIRMs) from a single hydraulic model (HEC-RAS 1D steady flow analysis) include uncertainty from different sources

## ➤ Objectives

- assess the uncertainty in FIRMs
- demonstrate the uncertainty propagation
- prioritize the relative impact of individual uncertainty sources
- compare 100-year BMA probabilistic flood maps with FIRMs

Image source:

[1] <https://msc.fema.gov/portal/home>

[2] <https://msc.fema.gov/nfh/>

FEMA Flood Map Service Center: Welcome!

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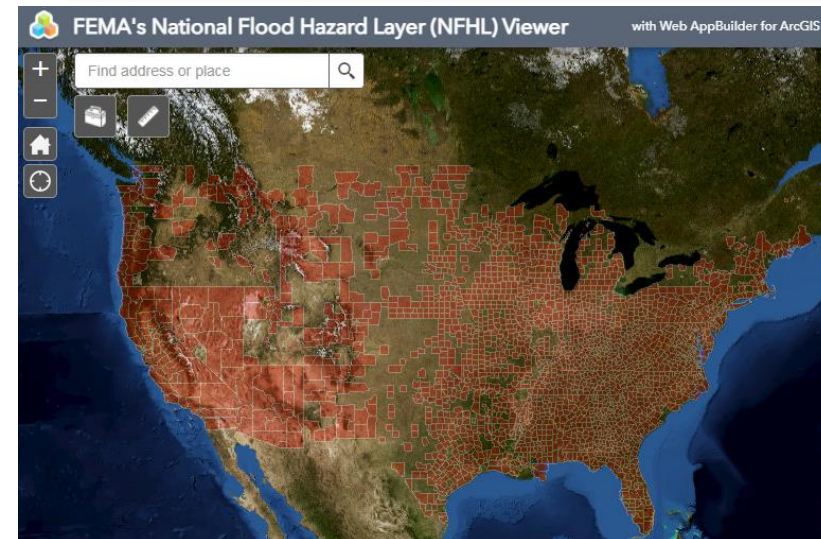
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[1]



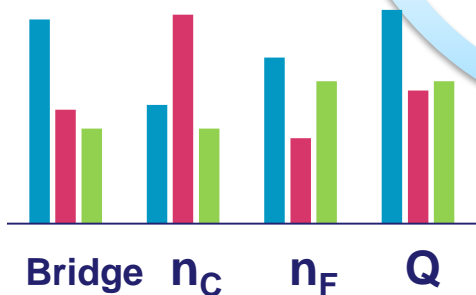
[2]



# Methodology

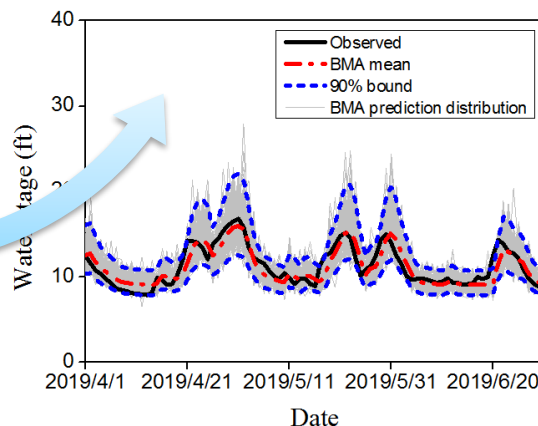
- Model structure (steady & bridge)
- Model parameter (roughness)
- Model input (streamflow data)

## Models of FIRMs



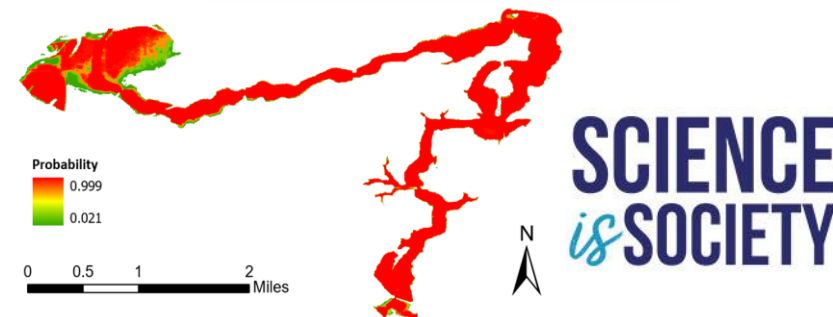
## BMA Analysis

- HEC-RAS model configurations
- Observed hydrologic data
- BMA weight & variance



- Prediction distribution of water stage
- Propagation of uncertainty
- Probability of inundation extents

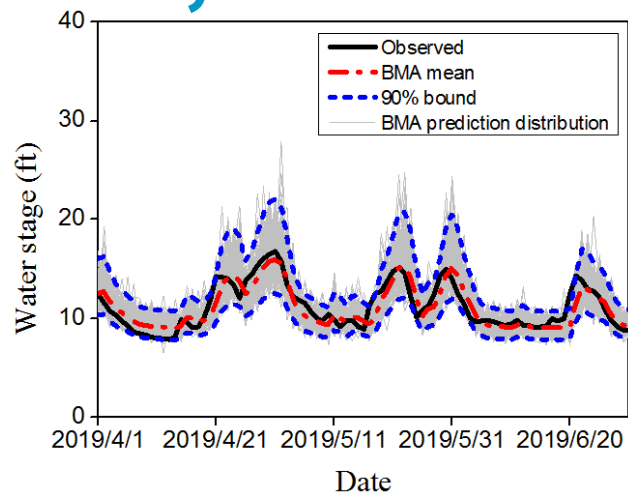
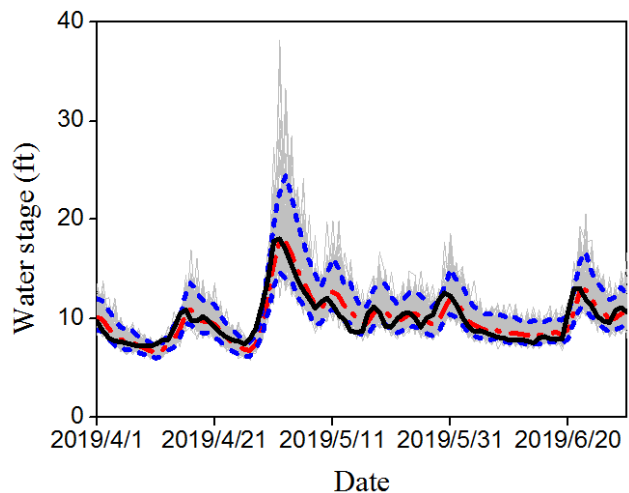
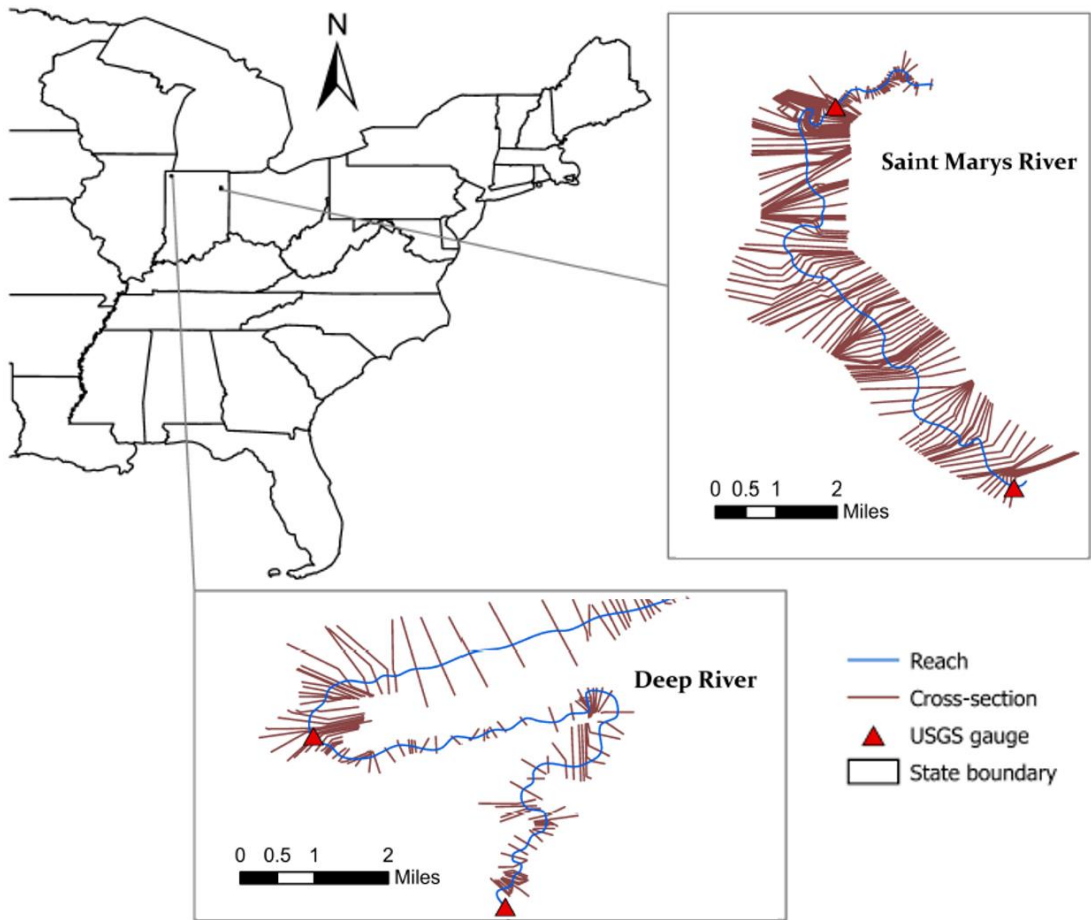
## Probabilistic Flood Maps







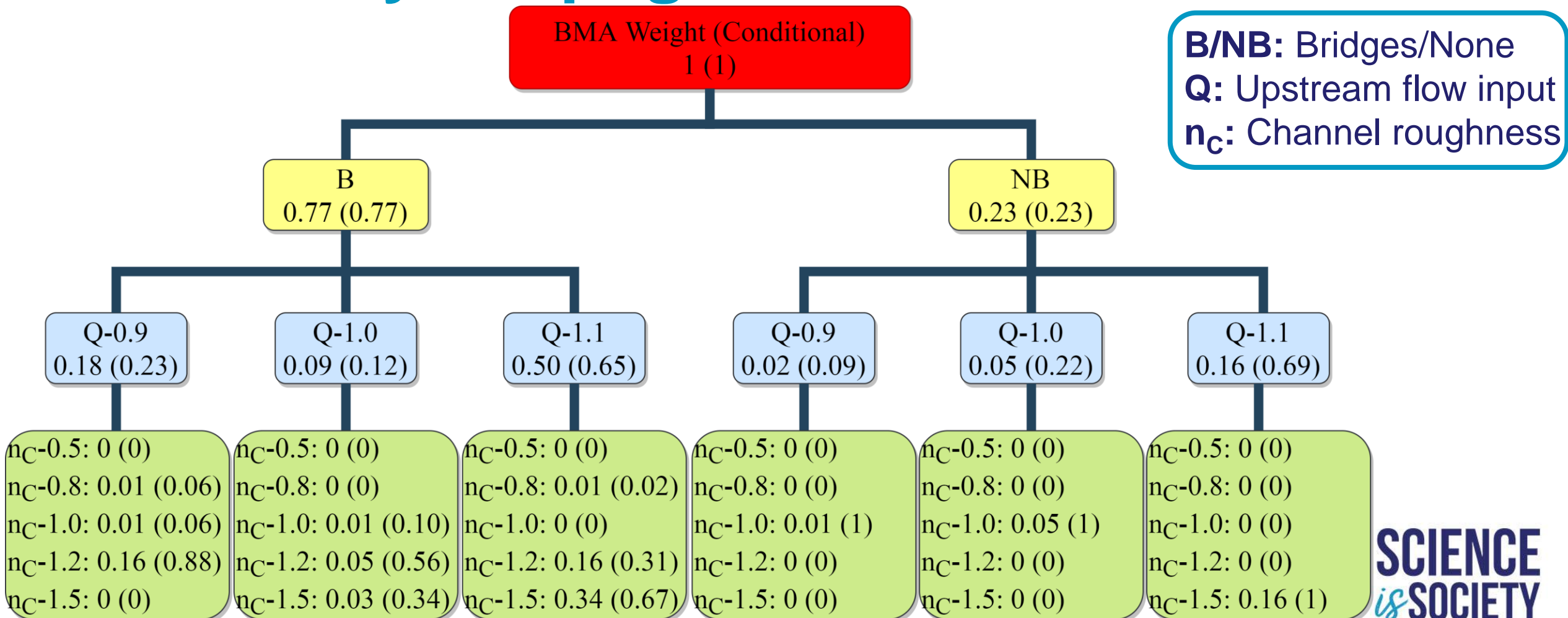
# Case Study of Two Rivers in Indiana, USA



Type	Uncertainty Coefficient	Deep River	Saint Marys River
UC1	90%-Prediction interval (Average interval width)	13.19% (3.35 ft)	4.40% (4.63 ft)
UC2	1-NSE	17.24%	21.61%
UC3	1-R <sup>2</sup>	17.05%	21.54%



# Uncertainty Propagation in HBMA Framework



# THANK YOU

“An answer that used to be a single number  
may now be a statistical distribution.”

— Nick Trefethen

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