

# Bayesian Model Selection for Hydro-Morphodynamic Models

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## Abstract

A good grasp of hydro-morphodynamic processes plays a major role in modern river management to accommodate its often-conflicting functions. In the last century, a variety of models has been developed to improve our perception of sediment transport and the resulting changes in river bed topography, using several empirical formulations. Therefore, there is a demonstrated need to establish a framework that helps the river engineer to select the closest model to the measurements.

This study suggested a Bayesian Model Selection (BMS) framework to direct the modeler towards the most robust and sensible representation of the hydro-morphodynamic conditions of the river under investigation. The proposed framework employs Bayesian Model Evidence (BME) resulting from Bayesian Model Averaging (BMA) as a model evaluation yardstick for ranking competing models. BMA performs a compromise between bias and variance, i.e. it blends a measure for goodness of fit with a penalty for unacceptable model complexity. This approach requires many model simulations, which are computationally expensive. However, this issue can be diminished by a mathematically optimal response surface via the aPC technique projects the original model. This response surface, also known as a reduced (surrogate) model, can exhibit the reliance of the model on all relevant parameters for calibration at high order accuracy.

The proposed framework was implemented in the model selection of two test cases; namely a test case model, based on an experiment done by Yen and Lee (1995) and a river model of a 10-km stretch of the lower Rhine, provided by the Federal Waterways Research Institute (BAW) in Karlsruhe. The results demonstrated that the proposed framework was acceptably able to detect the most representative model in which a good agreement existed between the simulation results and measurement data when the complete knowledge of initial parameters lacked. Further, the BMS framework could direct us to the most probable parameter regions for the task of optimization via probability density distributions of uncertain variables. Overall, this research fills a void in the literature with respect to selection of sediment transport equation for representation of hydro-morphodynamics of natural rivers. The suggested approach provides an objective guidance in the model selection to assist even less experienced users by reducing the professional expertise required for further optimization tasks.

**Keywords:** Hydro-morphodynamics, Bayesian model selection, Bayesian Model Evidence (BME), Response Surface, Arbitrary Polynomial Chaos expansion.