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Efficient uncertainty quantification in river intervention modelling through regression of correlated output

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Abstract: In river management, hydrodynamic models are used to predict the hydraulic effects of planned human intervention. Such interventions can range from small-scale vegetation management to large-scale flood risk reduction measures. Previous studies have shown significant uncertainty in the output of these models. However, despite the increasing call to be explicit about uncertainties of model output, high computational requirements prohibit systematic quantification of uncertainty in intervention effect studies.
We introduce a novel method that significantly reduces the computational requirements of uncertainty quantification for such studies. The main assumption of this method is that the model that describes the pre-intervention system and the model that describes the post-intervention system are correlated. We demonstrate that by modelling this correlation with probabilistic regression methods, the post-intervention model output can be described in terms of the pre-intervention model output. Therefore, a significantly smaller number of post-intervention model runs is required to quantify model output uncertainty.
We apply this method to quantify the effect of large-scale human interventions in the River Waal – a low-land river located in The Netherlands, Western Europe – using a detailed two-dimensional hydrodynamic model. We take into account multiple sources of uncertainty, including vegetation traits, river bed form roughness and misclassification in land use maps. Results show strong correlation between the reference pre-intervention model and the post-intervention models for various interventions. Results show a clear water level reduction resulting from the interventions and accurate estimates of both the uncertainty in water levels and intervention effect. Using this method only dozens of model runs with the post-intervention model were needed, compared to thousands with traditional Monte Carlo simulation.

***Keywords**:* uncertainty analysis; river; human intervention;