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Additional challenges for uncertainty analysis in river engineering

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The management of rivers for improving safety, shipping and environment requires conscious effort on the part of river managers. River engineers design hydraulic works to tackle various challenges, from increasing flow conveyance to ensuring minimal water depths for environmental flow and inland shipping. Last year saw the completion of such large scale river engineering in the 'Room for the River' programme for the Dutch Rhine River system, in which several dozen of human interventions were built to increase flood safety.

Engineering works in rivers are not completed in isolation from society. Rather, their benefits – increased safety, landscaping beauty – and their disadvantages – expropriation, hindrance – directly affect inhabitants. Therefore river managers are required to carefully defend their plans.

The effect of engineering works on river dynamics is being evaluated using hydraulic river models. Two-dimensional numerical models based on the shallow water equations provide the predictions necessary to make decisions on designs and future plans. However, like all environmental models, these predictions are subject to uncertainty.

In recent years progress has been made in the identification of the main sources of uncertainty for hydraulic river models. Two of the most important sources are boundary conditions and hydraulic roughness (Warmink et al. 2013). The result of these sources of uncertainty is that the identification of single, deterministic prediction model is a non-trivial task. This is this is a well-understood problem in other fields as well – most notably hydrology – and known as equifinality.

However, the particular case of human intervention modelling with hydraulic river models compounds the equifinality case. The model that provides the reference baseline situation is usually identified through calibration and afterwards modified for the engineering intervention. This results in two distinct models, the evaluation of which yields the effect of the proposed intervention. The implicit assumption underlying such analysis is that both models are commensurable.

We hypothesize that they are commensurable only to a certain extent. In an idealised study we have demonstrated that prediction performance loss should be expected with increasingly large engineering works. When accounting for parametric uncertainty of floodplain roughness in model identification, we see uncertainty bounds for predicted effects of interventions increase with increasing intervention scale. Calibration of these types of models therefore seems to have a shelf-life, beyond which calibration does not longer improves prediction.

Therefore a qualification scheme for model use is required that can be linked to model validity. In this study, we characterize model use along three dimensions: extrapolation (using the model with different external drivers), extension (using the model for different output or indicators) and modification (using modified models). Such use of models is expected to have implications for the applicability of surrogating modelling for efficient uncertainty analysis as well, which is recommended for future research.

Warmink, J. J.; Straatsma, M. W.; Huthoff, F.; Booij, M. J. & Hulscher, S. J. M. H. 2013. Uncertainty of design water levels due to combined bed form and vegetation roughness in the Dutch river Waal. Journal of Flood Risk Management 6, 302-318 . DOI: 10.1111/jfr3.12014