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Decomposing river model output uncertainty in its contributing sources: a Belgian case study

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The use of hydrologic and hydrodynamic models in flood forecasting systems is inevitably connected with the existence of errors and uncertainties. These uncertainties are often significant and should be recognized in any modelling application. Assessing the degree of uncertainty, its impact on model results and a decomposition in its major contributing sources is therefore critically important. This delivers decision makers additional information on model accuracy, on the relative importance of individual uncertainty sources and, hence, also on efficient approaches to reduce the total model output uncertainty.

In this paper, we demonstrate a data-based approach for uncertainty quantification and decomposition of river model outputs on a case study of the Belgian river Dender. Model input and model parameter uncertainties are assessed by comparing model results for uncertain inputs and parameters with historical observations or are based on expert elicitation. These uncertainties are subsequently propagated through the model, based on a Latin Hypercube Sampling procedure, to quantify the impact at locations of interest. The total model output uncertainty is separated in bias and variance components of all quantifiable error sources and a rest term uncertainty component that lumps the remaining unquantifiable and secondary error sources.

Performing a detailed uncertainty analysis within a tolerable timeframe is virtually impossible with a detailed full hydrodynamic river model. Instead, a grey-box model, based on a concatenation of reservoir elements, is used. This grey-box model succeeds in accurately reproducing the detailed model results, with an important reduction of computational burden.

The uncertainty decomposition results show that the relative importance of each uncertainty source is far from constant. The bias and variance contributions were found to vary over the range of modelled water levels and discharges, but they also differ spatially and for each model output type (water levels vs. discharges). The results of this uncertainty analysis and decomposition provide the modeler valuable insights on the system under study.