Dealing with the propagation of uncertainties in integrated catchment studies

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Summary

Integrated catchment models are abstractions of highly complex systems, which are dynamic and include both deterministic and stochastic processes. The stepwise process of abstraction from reality to model representation with its simplifications and idealizations of the real systems comes with the unavoidable occurrence of uncertainties. At present, a comprehensive uncertainty analysis is mainly applied in science and less in planning practice. Hence, the goal of this work is establishing a framework for practical application of uncertainty analysis and efficient data collection in planning practice in integrated catchment studies.

Introduction

Integrated catchment models are abstractions of highly complex systems, which are dynamic and include both deterministic and stochastic processes. These integrated catchment studies can be used to plan measures, to optimize systems as well as to evaluate the need of certain measures. The stepwise process of abstraction from reality to model representation with its simplifications and idealizations of the real systems comes with the unavoidable occurrence of uncertainties. The definition, recognition and consideration of these uncertainties is therefore of the utmost importance for applying such models and for the interpretation of model results.

Materials and Methods

Analysis of the occurring uncertainties in the planning process and communication of the results to the involved stakeholders is expected to lead to a more robust and cost-effective design and decision-making process. For example the usage of uncalibrated or poorly calibrated hydrodynamic models, which is still often the case in engineering practice, can have a high impact on the design process of urban drainage systems (Tscheikner-Gratl et al., 2016). Hence, the goal of this work is establishing a framework for practical application of uncertainty analysis methods and efficient data collection in planning practice of integrated catchment studies.

Uncertainties for these models regard mainly the used input data (e.g. rainfall data), the estimation of model parameters by calibration methods and uncertainties in the model structure itself (e.g. missing processes (Deletic et al., 2012)). Further sources of uncertainties are external influences, uncertainties regarding the numerical solution of the models and the so-called total ignorance of influencing parameters and processes. There exists a wide selection of different uncertainty quantification software platforms, each of them having unique strengths and weaknesses and being suitable for different kind of problems (Sawicka and Heuvelink, 2016).

Results and Discussions

The framework proposed here (see Figure 1) is an implementation of the framework for a global assessment of modelling uncertainties (Deletic et al., 2012) and uncertainty propagation analysis (Heuvelink et al., 2017) into integrated urban water modelling using the outlines proposed by (Belia et al., 2009; Muschalla et al., 2009; Bach et al., 2014).

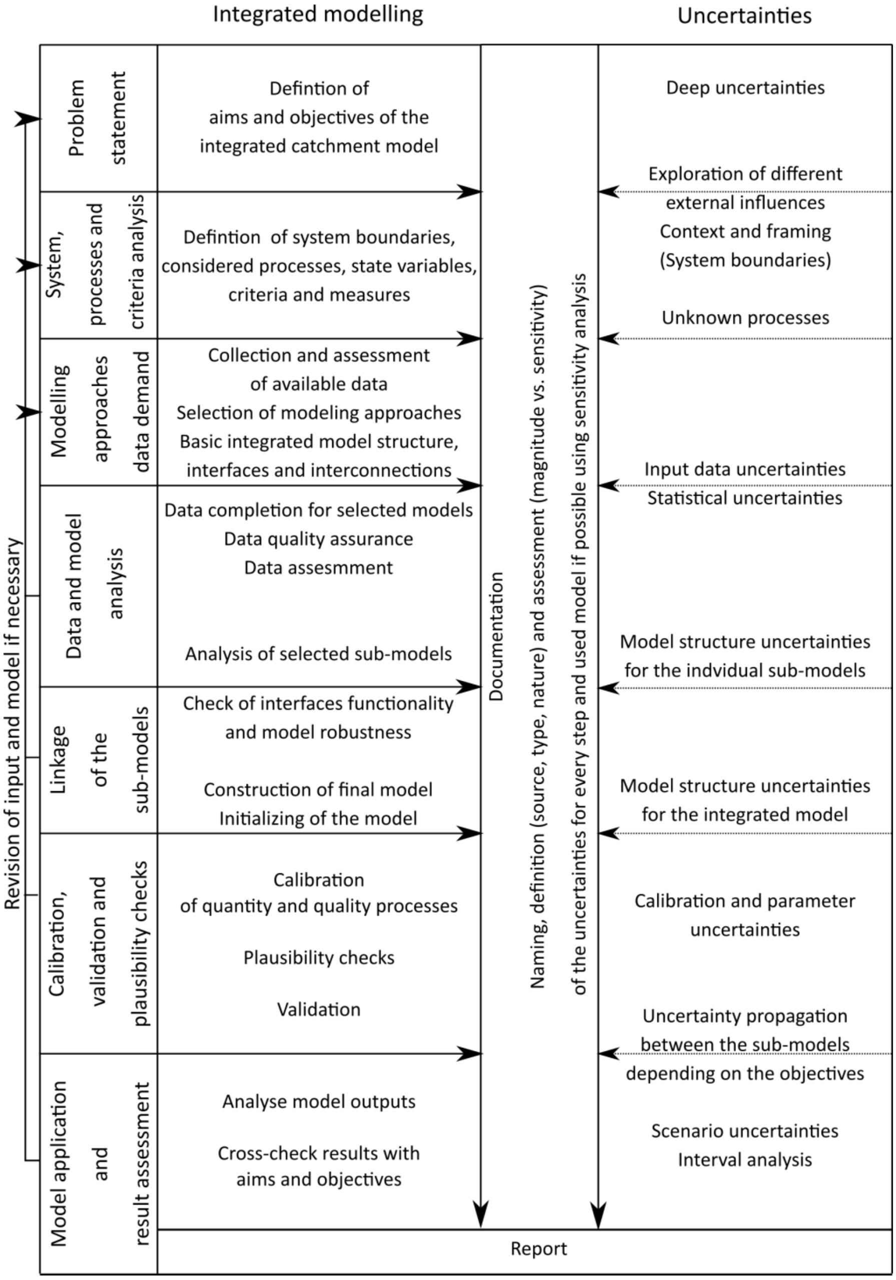

Figure 1: Framework for uncertainties in integrated urban water models

The process to construct and apply an integrated model can be subdivided into seven steps until a final report and assessment can be made. The used model and sub-models need to be revised and if necessary refined with every step, creating a feedback loop for the model. Contemporaneously with this process, a thorough continuous documentation of the information, data, changes and assumptions used during the process and the uncertainties of the before mentioned should be included to enable other people to comprehend what has been done and what every bit of data means. The treatment of uncertainties should therefore not be seen as one step included in model analysis or calibration, but rather as a continuous work accompanying the entire integrated modelling process.

Conclusions

The application in planning practice depends on the available data, computational resources and an equilibrium between effort, in terms of labour and costs, and the expected benefit. A basic uncertainty analysis of the model however should be part of any planning process. This includes applying a manual scenario analysis procedure including a most probable, worst and best-case scenario, and a plausibility check of measurement data and model results. The framework established by this project covers the bandwidth between these minimal requirements and more sophisticated methods, which are advisable for models assigned to more complex planning endeavours.

Acknowledgments

This work was carried out in the framework of the Marie Skłodowska Curie Initial Training Network QUICS. The QUICS project has received funding from the European Union's Seventh Framework Programme for research, technological development and demonstration under grant agreement no 607000.

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