DEALING WITH THE PROPAGATION OF UNCERTAINTIES IN INTEGRATED CATCHMENT STUDIES

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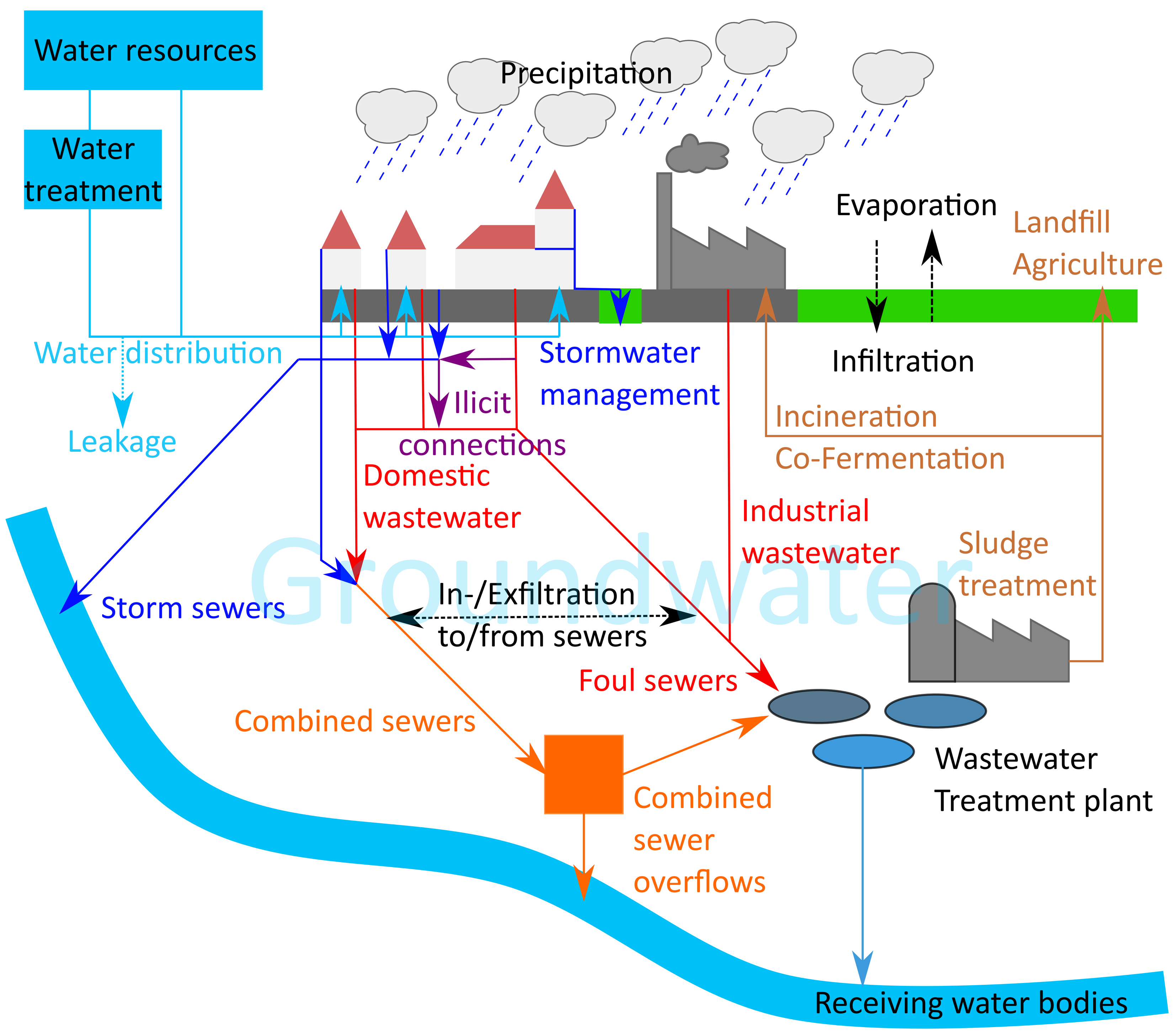
Introduction



Integrated modelling uses a set of interdependent components to construct an appropriate modelling system for a certain task. This joint modelling of two or more systems of the urban water system works by interweaving a sequence of sub-models for the various elements of the system. However, the integration of too many subsystems and processes irrelevant to the problem formulation can lead to unnecessary complexity (and errors) of the applied models. Furthermore, the decision on what is relevant for the actual question leaves room for subjective interpretation and differences of approach from the practitioners, who apply them 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

The framework proposed here is an implementation of existing frameworks for a global assessment of modelling uncertainties and uncertainty propagation analysis into a step-wise integrated urban water modelling approach, while expanding the scope of uncertainties incorporated. **The idea is to see uncertainty analysis not as a standalone and separate process from the usual modelling workflow but as an integral part of it.**

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 is incorporated here not as one step included in model analysis or calibration, but as a continuous work accompanying the entire integrated modelling process.

Resulting Framework

Revision of input and model if necessary

Step	Integrated modelling	Documentation	Naming, definition (source, type, nature) and assessment (magnitude vs. sensitivity) of the uncertainties for every step and used model if possible using sensitivity analysis — Uncertainties
Problem statement	Defintion of aims and objectives of the integrated catchment model		Deep uncertainties
System, processes and criteria analysis	Defintion of system boundaries, considered processes, state variables, criteria and measures		Exploration of different external influences; Context and framing (System boundaries); Unknown processes
Modelling approaches data demand	Collection and assessment of available data; Selection of modeling approaches; Basic integrated model structure, interfaces and interconnections		Input data uncertainties; Statistical uncertainties
Data and model analysis	Data completion for selected models; Data quality assurance; Data assessment; Analysis of selected sub-models		Model structure uncertainties for the indvidual sub-models
Setting up the integrated model	Check of interfaces functionality and model robustness; Construction of final model; Initializing of the model		Model structure uncertainties for the integrated model
Calibration, validation and plausibility checks	Calibration of quantity and quality processes; Plausibility checks; Validation		Calibration and parameter uncertainties; Uncertainty propagation between the sub-models depending on the objectives
Model application and result assessment	Analyse model outputs; Cross-check results with aims and objectives		Scenario uncertainties; Interval analysis
	Report		

Conclusion

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.

Further information available: **QUICS homepage and deliverables**
https://www.sheffield.ac.uk/quics/index

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