

Selecting the appropriate spatial detail and process complexity for modeling hydrological systems

Different conceptualisations can be chosen from when modeling environmental systems. As a result, a wide variety of models have been developed for analyzing the properties and behaviour of such systems when triggered by events. They are characterized by different levels of spatial detail, spatial complexity, and process complexity. At the time of their development, a trade-off was made between the required level of complexity, the accepted level of uncertainty, the data-availability and the performance of the model. As a result, the choices made with regards to the incorporated complexity are not necessarily straightforward and are highly dependent on the goal of the modeling exercise.

The spatial complexity can vary from lumped models in which all data and parameters are averaged over a given area, up to a high resolution spatially-explicit model operating at many small entities. Lumped models give rise to uncertainty due to the spatial aggregation, while distributed models suffer from uncertainty owing to data variability and measurement errors. The process complexity depends on the model structure and the complexity of the different equations used. Processes can be represented by means of a single empirical (transfer) function (black box), a conceptualization or a description of the underlying physics using the governing equations (mechanistic – grey/white box). Physically-based equations are assumed to be the best representation of the phenomena, but need a lot of data and, hence give rise to overparameterisation, and consequently, uncertainty. Empirical equations, on the other hand, can not be extrapolated to other situations without significantly increasing the uncertainty. It is recognized that there is no general model structure for all scales used, so the model structure and the process descriptions must be consistent with the spatial resolution of the model.

The aim of this study is to create a systematic methodology that helps in choosing the most appropriate combination of the spatial detail and the process complexity in function of the specific conditions of the system, the available data and the objectives of the study. The latter depend on existing environmental policies and regulation, the assessment of management practices, scenario-analysis, etc.

A case-study will be presented to compare different model formulations corresponding to selected model objectives for water quality modeling. Sensitivity analysis of a mechanistic model of the catchment will be used to identify dominant processes, to gain an insight into possible simplifications of the model and to draw up guidelines in the development of a parsimonious model. By varying the attributes of the catchment, the input data and the spatial arrangement of the model, different options in setting up a simplified model will be assessed and a more general methodology will be extracted from the gained information. The incorporation of a proper uncertainty evaluation will be essential in order to compare different conceptualisations and making suitable selections. A second case-study will be used to evaluate the developed methodology.