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Preface

Uncertainty in environmental and hydrological mathematical modelling

Engineers are increasingly called to deal with practical problems related to water resources management, risk analysis, environmental engineering and water pollution. Providing a way forward to solve the above questions requires setting up mathematical models that are affected by uncertainty, that in many cases is relevant. In fact, the theories that are employed for providing solutions to engineer's problems are not exact sciences: even if it is methodologically rigorous, it is incapable of producing precise results, for the presence of inherent randomness that translates in indeterminacy and therefore uncertainty. To cope with uncertainty is a challenge for scientists and practitioners, requiring the application of proper procedures for model identification, parameter calibration, hypothesis testing, model testing (also called model validation) and finally uncertainty assessment. As a matter of fact, uncertainty estimation in hydrological surface and subsurface modelling is today one of the most important subfields of hydrology, according to the numerous contributions presented by the recent scientific literature. Uncertainty estimation is also a relevant topic in environmental modelling that is usually characterised by the need of analysing complex processes and by the difficulties due to insufficient and often unreliable data. While quantitative uncertainty assessment is often considered a relatively new topic, it is worth noting that modellers were aware of uncertainty and used to deal with it since the first studies and applications were carried out. In particular, empirical techniques were used to compensate for the lack of information about model reliability. For instance, modellers are well used to adopt safety factors or allowance for freeboard, which are usually set basing on consensus, expert opinion and empirical evidence. These safety factors were the first and very useful tools to take into account inherent uncertainty and imperfect knowledge of processes in design. However, expert knowledge is by itself subjective and referred to specific contexts and situations. The call for a generalised and systematic approach to uncertainty estimation is the motivation for the renewed interest in the past few years. A reason limiting the use of uncertainty assessment methods is that the transfer of the know-how about uncertainty in hydrology from scientists to end-users was, and still is, difficult, notwithstanding the relevant research activity mentioned above. A relevant problem is that uncertainty assessment suffers today from the lack of a general theoretical scheme. The result of this situation is that it is extremely difficult to obtain a coherent picture of the available methods. This lack of clarity is an example of "linguistic uncertainty". Therefore, much is still to be done to reach a coherent treatment of the topic. Uncertainty assessment is particularly related to engineering. In fact, the above reasoning highlights that design variables are uncertain, therefore impacting the project of civil engineering structures and the development of flood protection and water resources management strategies. This is the reason why engineers are much interested by recent progresses in uncertainty assessment that were supported by intensive research efforts worldwide.

Despite the important role played by the uncertainty, historically the uncertainty estimation is only a common practice in hydrology field and methodological contributions originate from such a field. Nowadays, uncertainty estimation is becoming very spread also in other fields (such as wastewater treatment and urban drainage). As a matter of fact, very recently two Task Groups under the International Water Association umbrella have been constituted. One of the main challenge faced by both researchers and practitioners is: is it possible to successfully transfer these methods to other water disciplines?

The awareness of the above relevance of uncertainty and the idea to give an answer to the above question motivated the Italian community, and in particular the researchers working at the University of Palermo, in Sicily, to promote an international session devoted to uncertainty in environmental and hydrology modelling during the XXXII edition of the Italian National Conference of Hydraulics and Hydraulics Constructions. The session was attended by eminent researchers at the international level coming from different water disciplines who presented a variety of studies with applications to urban drainage stormwater modelling, water quality modelling, rainfall–runoff transformation in urban and natural catchments, wastewater treatment plant modelling.

The special issue presented here collects selected papers that were presented to the above session. We sincerely hope that they can serve as a reference for anyone dealing with uncertainty in environmental and hydrological mathematical modelling. The purpose of this review is to provide an overview of the current issues about uncertainty assessment in our field.

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