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Modelling in Europe - the Importance of Environmental Hydraulics

Hydrolink

Modelling in Europe: the Importance of Environ

Nowadays society faces important and global environmental problems. Many of them relate to fluid dynamics which can be parameterized by hydraulic variables. The analysis of these problems related to environmental hydraulics has as a common topic, the need to solve complex non linear equations, which are time dependent. And the solution of these complex problems requires accurate modelling techniques.

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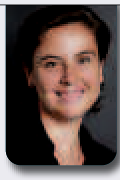

Hydraulic and environmental research is directly linked with modelling. There are some powerful reasons behind this fact: On the one hand, the investigated problems have such a complexity that their study requires models to represent the reality. On the other hand, environmental problems sometimes simply cannot be represented by reality (let´s imagine dispersion of a particularly dangerous pollutant in a river) and numerical models are then the more suitable process to study these possible effects.
Our research deals with fundamental aspects of life. Water and its contamination are present in many of our daily actions. Thus, the representation of phenomena related to water movement and the transport of pollutants covers a wide range of impacts over life and the environment. The problems faced by enviro-hydraulic models generally involve extreme complexity, and typically characterized by strongly nonlinear evolution dynamics. The systems have many degrees of freedom; this makes them complicated and implies nonlinear interactions of several different components taking place on a vast range of time-space scales: continuum considerations and turbulence implications are required for solving resultant equations systems. Theoretical, experimental and computational solutions must be combined to obtain simple answers for complex questions.
In past centuries these problems were studied by considering mostly physical or theoretical approximations. In some particular cases theoretical solutions can be applied. Nevertheless, the presence of strong variability of both the outputs of theoretical models and of the real systems in many cases contributes to difficulties in the applicability of such analytical solutions in terms of model reliability. Therefore, there are some problems which are not suitable to be represented by any theoretical analysis, while their modelling becomes of a paramount importance. Unfortunately, only too often, the theories relevant for the study of systems having a lower degree of complexity cannot be applied to real, non-steady and turbulent problems such as those related to environmental hydraulics modelling.
Furthermore, hydraulic and environmental research are also strongly based on physical models. They play a fundamental role in current and past investigations. Physical models reproduce real phenomena at reduced scale by using dynamical similarity. Large hydraulic facilities are particularly indicated for natural representations without distortions. But also engineered applications of hydraulic modelling are particularly recommended by experimental devices. In real environments, field data are especially difficult to be used to draw conclusions because of uncontrolled natural perturbations. In contrast, the predictive capability of models is increased by laboratory experiments: in this case measurements are performed under controlled circumstances and the uncertainty confidence intervals of predictions are considerably reduced.
Nowadays, computer simulations have become a useful part of enviro-hydraulics research. The development of numerical techniques for solving equations and the increasing capability of computers to provide prediction in a detailed, continuum, cheaper, visual and easy manner has contributed very much to this fact. Computational models provide a perfect complement for experimental facilities.
Computer simulations vary from computer programs that run in a few minutes, to network-based systems that can calculate complex problems iterating over hours or days. Nevertheless, numerical models are only approximations to processes. Uncertainty analysis, calibration and validation techniques must be carefully applied. This phase is decisive for using the model predictions to represent the future behavior of real systems. The final objective of modelling is attempting to find solutions to real problems and thereby enable the prediction of the system from a set of parameters and initial conditions. Therefore, the model has to be consistent. It requires a compromise between detail and simplification: as many points as possible should be taken into account; while an appropriate treatment of the data should be considered, so that reality is simulated in the most simple and appropriate possible way. Nowadays, CFD (Computational Fluid Dynamics) techniques have become a more precise tool even for non-expert modellers. Many commercial codes are easily available for researchers and many applications are arising with them.
It must be considered that modelling entailed in solving enviro-hydraulics problems is a simplified representation of complex turbulent processes and boundary conditions; therefore, the calibration, validation and testing of simulations becomes of paramount importance in the whole modelling process. Especially in the case

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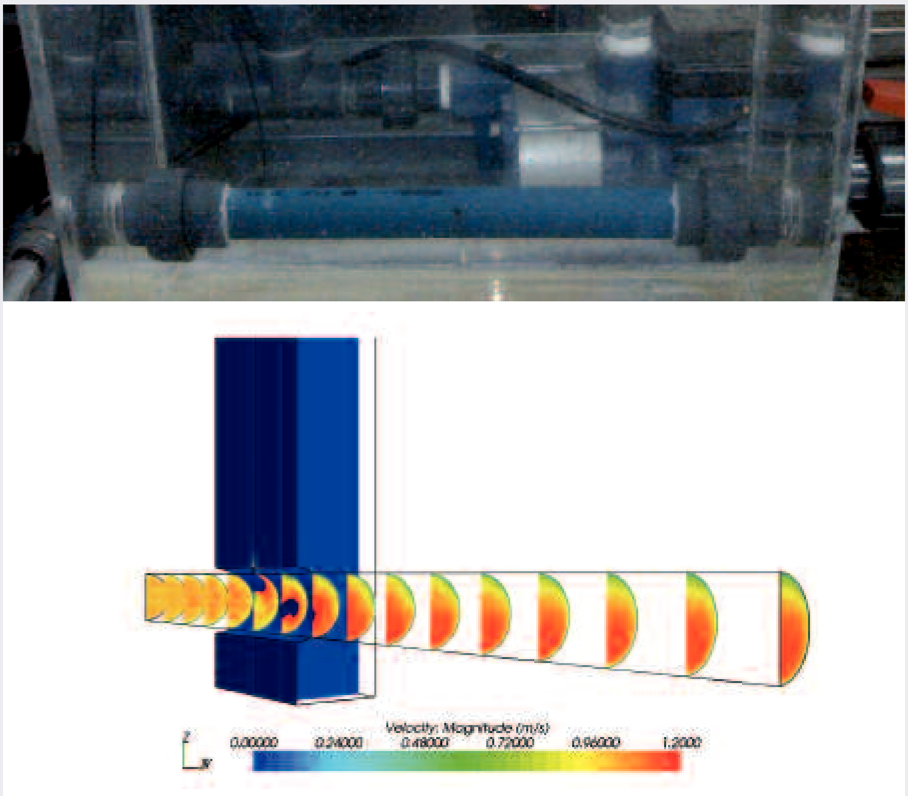

of numerical simulations, where beautiful coloured representation of results could hide inaccuracies, validation is a crucial task for researchers! Actually, optimization techniques are being developed quickly and even procedures such as genetic algorithms, neural networks, fuzzy logic and any sort of statistical evolutionary algorithms are the future of numerical model modelling and calibration with experimental contrasted results: No validated model will enable us to take decisions about real systems behaviour.

No simple technique is perfect for every kind of modelling. Redundancy and combination of strategies is the better solution for simulating real environmental and hydraulic problems. A good proof of this synergic combination of solutions for modelling has been achieved in Valencia (Spain) last October. IWEH09, a Workshop sponsored by IAHR (International Workshop of Environmental Hydraulics: Theoretical, Experimental and Computational Solutions) has been an excellent opportunity to present, demonstrate and discuss research, development, applications, and the latest innovations and results in this important field. Very important examples of the capacity of modelling for enviro-hydraulic problems can be found in Europe, i.e.: Deltares in Delft (Netherlands), DHI research group in Denmark, CEDEX in Spain, Institute for Hydromechanics in Karlsruhe, Germany, among many others. Some brilliant computational codes and numerical techniques have been developed using the combined efforts of the researchers involved in these groups, widely used in Europe and all around the world.

The future of environmental hydraulic simulations was foreseen in the 82 contributions presented in this workshop. A wide range of aspects were covered, regarding environmental and hydraulic simulations, i.e.:

- *Mathematical and numerical modelling;* presenting models covering such different aspects as optimization designs in open channels, simulation of flows in river and basins, and simulation of engineered devices as membrane reactor models based on neural networks
- *Turbulence modelling:* modelling in meanders, viscous models, swirling strength analysis, groined fields.
- *Dispersion and transport:* solute transport modelling, effects of sedimentation, bed river interactions.
- *Experimental experiences:* river biofilm growth, flow and deposit patterns in reservoirs, biological and ecological experiences, biofilm stabilization of non-cohesive sediment, air-water flow modelling in pipes.
- *Water andnvironmental engineering and hydroinformatics:* of pipelines and valves models, disinfectant simulation in reservoirs and pipes, fuzzy models for hydraulic applications, modelling of urban growth and risk analysis in enviro-hydraulic systems, watershed models.

We had the enormous privilege to count upon the presence of Dr. Gerhard Jirka opening our workshop with his keynote: “Environmental Fluid Mechanics: Definition, Methods and Applications”. He reminded us how physical models can simulate real phenomena such as jets, atmospheric turbulence and dispersion, and sending us his always encouraging message to combine theoretical, experimental and numerical techniques for giving solution to future enviro-hydraulics models. Citing his words prefacing our Workshop *“Environmental hydraulics” with its focus on the flow-associated mass and heat transport processes and on the flow interaction with the biological and ecological components of our water systems, transcends the traditional hydraulic approach”*. I specially would like to acknowledge him and all the other prominent researchers in our field like him, who generously open research doors for the future in environmental and hydraulic modelling. Sadly Prof Jirka is no longer with us – but he will be remembered always for the fundamental contribution he made to our subject!