Water science: a solution oriented development of research and education

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Abstract

The past 30 years have marked a tremendous advance in water science. Increasing computing power and innovative monitoring techniques have provided exciting perspectives for assessing and managing water resources at the global level, within the broad context of geosciences. These progresses have been well summarized by the special collection of Water Resources Research "Legacy and Perspectives for the Science of Hydrology", that was published in 2015 to celebrate the 50th Anniversary of the journal. However, the technical progresses in water resources management and hazard mitigation have been less evident. As a matter of fact, our capability to address local and global water challenges did not improve much since Klemes (1986) stated "In all these cases, mathematics has been used to redefine a hydrologic problem rather than solve it. Box [1976] calls such use of mathematics "mathematistry".....".

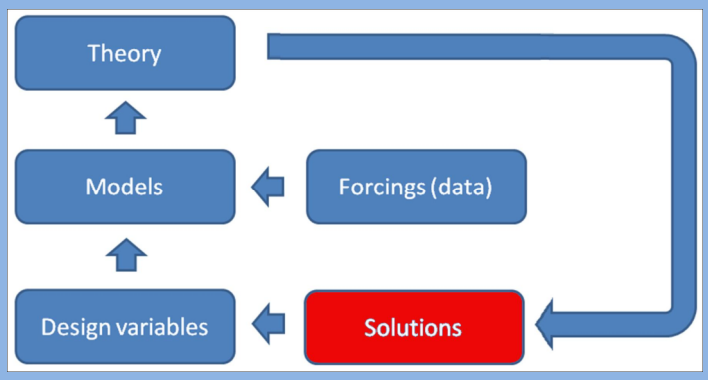
The reason why the achievements in observing and understanding water processes were not finalized into technical and practical progresses is still debated. In my opinion, the main weakness has been a lack of focus on the final step that water science needs to make in order to improve technical tools. Therefore, the gap between research and engineering, between knowledge and solutions, became larger and larger.

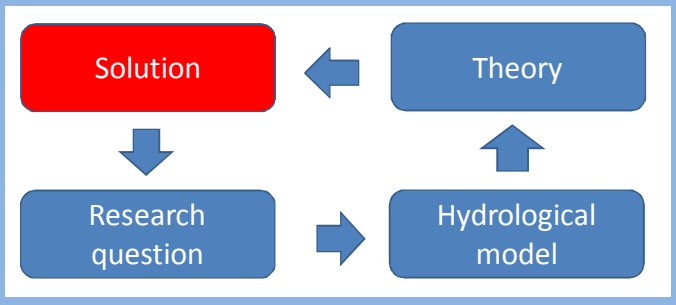
The above situation calls for a paradigm shift in research and education in water science, as well as new practices in scientific publishing and academic procedures for evaluating scientific merit. A solution-oriented approach is needed, in view of the global call for improving management of water resources and mitigating water related risks. The paradigm shift needs to be orchestrated by recognizing the solution as the main target for water science, while research and education should in turn be considered as inseparable propellers for stimulating a solution-oriented development.

Finally, education and research in water science needs an innovative focus on the human impact, by adopting physically-based stochastic modeling as an effective tool for incorporating knowledge of water and societal processes into an integrated and innovative stochastic framework focusing on solutions.

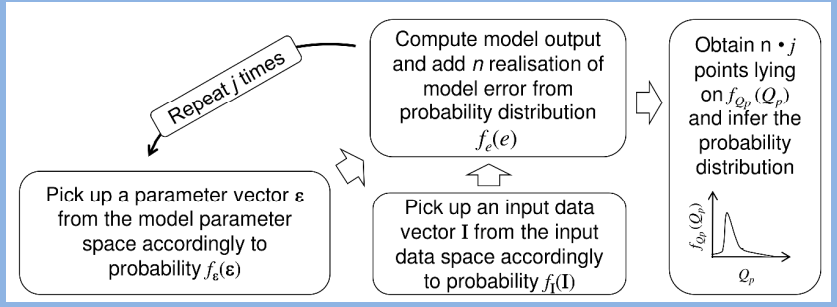
Solution based approach to education

- Application as the main target of education – Lectures should not necessarily start from the underlying theory but rather from applications.
- Interaction with the students is the main driver of education.
- Supporting material should be openly available from the web, together with video tapes of the lectures.
- Books are dead – Use of dynamic supporting material periodically checked to ensure that up-to-date information is used.
- Use of social networks to provide supplementary information and to keep in contact with students. Relationship with professors is not limited to lectures
- Advanced use of computer, web-based applications and software
- Field trips should focus on technical details related to societal problem solving.





Algorithm for physically-based stochastic modelling



Solution based approach to research

- Research questions should focus on providing solutions to global water challenges.
- Research questions should focus on how to use advanced information and communication systems to improve the performances of hydrologic design.
- To get to target, a innovative focus is needed on the interaction between humans and water systems.
- Research activity should promote the use of open software and open data, open information in general.
- Reproducibility of experiments and applications must become an essential prerequisite.
- A new culture of case studies is needed. Case studies should lead to conclusions with general validity.
- In order to focus on practical applications and interaction with human systems, we need an innovative approach to deal with uncertainty. Providing reliable and meaningful estimates of uncertainty is necessary for supporting decision makers.
- Physically-based stochastic modeling as a tool to make an integrated assessment and estimation of uncertainty.

References: Montanari, A., & Koutsoyiannis, D. (2012). A blueprint for process-based modeling of uncertain hydrological systems. Water Resources Research, 48(9)
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