Recent experiences in dealing with complexity and dimensionality in water resources management

Andrea Castelletti
(Politecnico di Milano), March 5, 2010

Decision-making in large water and related land systems is faced with a twofold challenge: the complexity of the physical domain in which decisions are taken, where most of the processes are dynamic, spatially-distributed, highly non-linear and involve a large number of variables (high dimensionality), and the heterogeneousness of the socio-economic-ecologic context they affect, which usually involves multiple (often many), conflicting objectives. Improved data collection techniques as well as increasing computing power are opening up new opportunities for the development of sophisticated physically-based models that can accurately reproduce hydrodynamic and bio-chemical conditions of water bodies, and their variability in space and time. Although this increased model complexity is considered a virtue for scientific purposes, it is a definite disadvantage in water resources planning and management, where the computational limitations of traditional optimization methods restricts model applicability to "what if " analysis over a few, a-priori defined alternative decisions. This is particularly critical in multi- objective contexts, where the concept of optimality is expanded into the more computationally onerous Pareto optimality. In addition, most of water resources systems are composed of a large number of constituencies and interdependent subsystems, for which even simple lumped representations might result in extremely high computational burdens. In this talk I will propose some recent ideas we explored to operationally integrate science-oriented models and optimization algorithms in multi-obejctive decision-making: the use of emulation modelling techniques to reduce large physically-based models to low- order computationally-efficient models, identified over synthetic data generated via simulation of the original model; combined with a partial model-free, batch mode reinforcement learning that allows for directly using data sets generated with either distributed or lumped (e.g., emulation) models, as well as historical time series.

Andrea Castelletti's short bio

AC received a MS degree in Environmental Engineering and a PhD in Information Engineering from Politecnico di Milano, Italy, in 1999 and 2005. Since 2006 He is Assistant Professor of Management of Natural Resources in the same university where he works with the research group on Planning and Management of Environmental Systems at Dipartimento di Elettronica e Informazione. Since 2007 he is Adjunct Research Fellow at the Centre for Water Research of the University of Western Australia. His main research interests focus on participatory and integrated modelling and control of environmental systems, namely water resource systems, and Decision

Support System design. He is co- author of two international books on integrated water resource management and of a number of papers in international journals and conference proceedings. Since 2008 he is chairing the IFAC Technical Committee on Modelling and Control of Environmental Systems (TC 8.3).