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Seeking parsimony in hydrology and water resources technology

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The principle of parsimony, also known as the principle of simplicity, the principle of economy and Ockham's razor, advises scientists to prefer the simplest theory among those that fit the data equally well. In this, it is an epistemic principle but reflects an ontological characterization that the universe is ultimately parsimonious. Is this principle useful and can it really be reconciled with, and implemented to, our modelling approaches of complex hydrological systems, whose elements and events are extraordinarily numerous, different and unique? The answer underlying the mainstream hydrological research of the last two decades seems to be negative. Hopes were invested to the power of computers that would enable faithful and detailed representation of the diverse system elements and the hydrological processes, based on merely "first principles" and resulting in "physically-based" models that tend to approach in complexity the real world systems. Today the account of such research endeavour seems not positive, as it did not improve model predictive capacity and processes comprehension. A return to parsimonious modelling seems to be again the promising route. The experience from recent research and from comparisons of parsimonious and complicated models indicates that the former can facilitate insight and comprehension, improve accuracy and predictive capacity, and increase efficiency. In addition – and despite aspiration that "physically based" models will have lower data requirements and, even, they ultimately become "data-free" – parsimonious models require fewer data to achieve the same accuracy with more complicated models.

Naturally, the concepts that reconcile the simplicity of parsimonious models with the complexity of hydrological systems are probability theory and statistics. Probability theory provides the theoretical basis for moving from a microscopic to a macroscopic view of phenomena, by mapping sets of diverse elements and events of hydrological systems to single numbers (a probability or an expected value), and statistics provides the empirical basis of summarizing data, making inference from them, and supporting decision making in water resource management. Unfortunately, the current state of the art in probability, statistics and their union, often called stochastics, is not fully satisfactory for the needs of modelling of hydrological and water resource systems. A first problem is that stochastic modelling has traditionally relied on classical statistics, which is based on the independent "coin-tossing" prototype, rather than on the study of real-world systems whose behaviour is very different from the classical prototype. A second problem is that the stochastic models (particularly the multivariate ones) are often not parsimonious themselves. Therefore, substantial advancement of stochastics is necessary in a new paradigm of parsimonious hydrological modelling.

These ideas are illustrated using several examples, namely: (a) hydrological modelling of a karst system in Bosnia and Herzegovina using three different approaches ranging from parsimonious to detailed "physically-based"; (b) parsimonious modelling of a peculiar modified catchment in Greece; (c) a stochastic approach that can replace parameter-excessive ARMA-type models with a generalized algorithm that produces any shape of autocorrelation function (consistent with the accuracy provided by the data) using a couple of parameters; (d) a multivariate stochastic approach which replaces a huge number of parameters estimated from data with coefficients estimated by the principle of maximum entropy; and (e) a parsimonious approach for decision making in multi-reservoir systems using a handful of parameters instead of thousands of decision variables.