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Stochastic physically-based modelling in hydrology: towards a synthesis of different approaches for a new target

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Stochastic physically-based modelling is a classical concept that seems to have been forgotten by hydrologists. In fact, in recent years there has been an increasing focus on deterministic physically-based modelling (often briefly called physically-based modelling) of hydrological systems, with the aim to pursue a deterministic representation of the involved processes. We argue that stochastic physically-based modelling should be re-discovered. In fact, it is a powerful means to effectively synthesize our knowledge and understanding of natural systems within a framework that takes into account the unavoidable and inherent uncertainty, thereby synthesizing hydrological modelling and uncertainty assessment. Another reason favouring this re-discovery is the present availability of computing power, which makes the stochastic representation of complex models a feasible option.

We present a modelling framework where physical information is fully incorporated in a stochastic approach, thereby taking full advantage of the available knowledge while accounting for, and quantifying, the related uncertainty. Within this view, stochastic and deterministic representations are not antitethic but rather complementary and can be synthesized in a stochastic physically-based approach. Input and output variables can be provided in the form of probability distributions, if they are uncertain, and the hydrological model can be incorporated in the form of probabilistic equations. The resulting approach is not much different to what hydrologists are already used to apply, and allows one synthesizing the results of the recent literature on deterministic, physically-based, modelling and uncertainty assessment.

We present applications to synthetic and real world case studies and discuss the appropriateness of the underlying assumptions.