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Hydrological Catchment Modeling: Past, Present and Beyond

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This paper discusses a number of fundamental issues in flood prediction and forecasting ranging from the role of physically based models and/or data-driven models to the concepts of predictive uncertainty and equifinality.

From the original Rational Method to the presently available distributed hydrological model, a vast evolution of conceptualization and parameterization of the hydrological processes in catchment models has taken place as the result of more than a hundred years of research .The value of this research, which aims at describing in physical terms the hydrological phenomena from the pixel to the catchment scale (or vice-versa) is not fully acknowledged by the proponents of data driven models or of "data mechanistic models" not strictly requiring the definition of the rigid model structures originating from the physical balance equations.

It is difficult to demonstrate the superiority of one approach over the other, but, although recognizing the value of the data-driven models, a danger exists in broad philosophical terms: namely the risk that all the work to better understand the processes and their representation at the different space and time scales can be neglected on the grounds that it is not necessary. It is therefore time that the hydrological research community designs the appropriate test-beds to determine the roles and fields of application of the different types of models. Furthermore, the recent introduction of the "equifinality" principle, instead of leading to possible solutions, has amplified the dissatisfaction with the physically based models on the grounds that their parameter uncertainty is enormous. Again it is time that the hydrological research community, with the support of knowledgeable statisticians, agrees on the principles of "predictive uncertainty" and on the counter-principle of "inequifinality", namely the objective of appropriately constructing less diffuse posterior parameter distribution functions that

properly reflect the quantity of available data as indeed they do for the data-driven models. These can then be used for marginalizing out the parameter uncertainty to deliver more appropriate measures of predictive uncertainty. Only by having the same framework for estimating predictive uncertainty for both data-driven and physically based models can test-beds be constructed whereby their predictive merits and roles can be properly established.