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How inputs of an hydrologic model have to be adjusted to its underlying physical hypothesis? Case study on the Lez hydrodynamic modeling (Southern France)

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Karst aquifers are famous for their high heterogeneity and non-linearity and are currently badly understood whereas they are a major issue on both flood forecasting and water resources. Conceptual models, for example based on reservoir concept, are often used in order to simulate their behavior (1). Nevertheless reservoir models are sensitive to their initial conditions, which are often difficult to measure because of the heterogeneity. Consequently a lot of research is devoted to black-box modeling, particularly neural networks, which can be viewed as an interesting method to deal with non-linearity without other measurement acquisition than system input and output (2).

In Mediterranean regions, due to the variability of rainfalls during the hydrologic cycle, the availability of water during summer poses a difficulty to stakeholder. Consequently, the conurbation of Montpellier (400 000 inhabitants), Southeast France, investigates pumping through boreholes in the drain of the Lez spring (3), the major outlet of Lez karstic aquifer, studied from most than 40 years and emblematic of the complexity of karst aquifers. Indeed, the heterogeneity of both the karst system due to geologic complexity, and of rainfalls, joint with the emptying of the spring by pumping contribute to modeling difficulties.

Thereby it seems relevant to use neural networks, as non-linear machine learning models, in order to manage the lack of knowledge about the Lez system. The aim of the modeling approach was to simulate the level of water in the drain of the Lez spring in order to better appreciate the level of emptying during summer just before refilling by the autumn rainfalls. To this end the multilayer perceptron was used thanks to its two main properties: universal approximation and parsimony regarding to other non linear statistical model.

Particularly, the role of evapotranspiration is not well defined or estimated for karst aquifers (4,5) whereas it is of major importance for water resource. In this context, the communication presents the modeling approach of rainfall-water table level modeling using successively a multilayer perceptron and a reservoir model, already designed for the Lez spring (1). The objective is to compare models behavior and sensitivity relatively to the input variable evapotranspiration. Three different rainfalls series were thus derived depending on the hypothesis about ETP: measured rainfall, efficient rainfall and measured rainfall joint with a priori evapotranspiration. The last is a sinusoidal curve with maximal value in July.

Faced to these inputs, the reservoir model exhibited significantly different behavior to input variables. Surprisingly, the best reservoir model was obtained using the input with less explicit physical information: the rainfall in conjunction with sinusoidal ETP. This model provides a Nash criterion of 0,80 when the model with efficient rainfall provides a Nash of 0,59. At the contrary, the neural network model gave equivalent results insensitive to difference of rainfalls (Nash criteria between 0,81 to 0,86).

It is thus interesting to conclude that the less physical model (NN) do not necessitate explicit physical information to correctly estimate the karst behavior, whereas the conceptual model was not able to deal with inaccurate ETP.

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