Robust calibration of a hydrological model with stochastic surrogates

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Abstract

Misspecifying external forcings (such as rain) on a hydrological model can directly affect subsequent parameter calibrations. Indeed, by using classical calibration and problem inversion methods, the error in the external forcings is propagated to the model output, and then, if not treated correctly, this error is compensated by overcalibrating the model parameters. As a consequence, parameter values that were found optimal for one value of the external forcings, are not granted to be optimal for another one. Ideally however, estimated parameter values (that describe time-invariant soil properties) should be the same no matter the value of the external forcing.

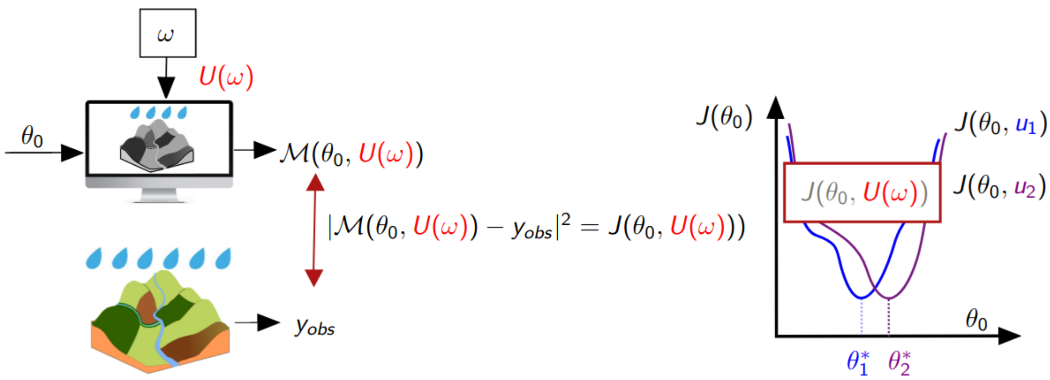

Figure 1: The influence of stochastic external forcings $U(\omega)$ on the calibration. The aim is to estimate the parameter θ_0 that minimizes the distance between model simulations $\mathcal{M}$ and terrain observations y_{obs}. This distance is quantified through a cost function $J(\theta_0, U(\omega))$. However, the cost function depends on the realization of the random variable $U(\omega)$, hence its minimizer θ^* does too. The aim of robust calibration is to annul this dependence.

Robust calibration was proposed to reduce the dependence of the estimated parameter values on the external forcings [3]. The aim of robust calibration is to propose parameter estimators which are satisfactory over a large set of values of the external forcings. We model the external forcing (here, the rain) as a random variable, and want the estimated parameter to be "optimal enough" over a set of probable values of the random variable. We will be interested in the following robust estimators: the minimizer of the mean of the cost function, the minimizer of its variance, and the Pareto front of these two objectives.

As robust calibration is difficult to apply on distributed hydrological models, mainly due to their high dimension and computational cost, we use a surrogate model for the cost function. The stochastic surrogate for the cost function is constructed as proposed in [1]. Indeed, in a context where rain forcings are considered stochastic, the cost function to be minimised in the calibration setting is itself stochastic, Figure 1. Furthermore, this approach is non-intrusive as the structure of the stochasticity in the rain is never used, only an external stochastic rain simulator is needed.

We present the robust calibration of the PESHMELBA [2] distributed, process based, hydrological pesticide transfer model used for the simulation of pesticide fate on small agricultural catchments. The case study is a small virtual catchment in the Beaujolais region. Here, we focus on the calibration of two parameters, the soil content at saturation in deep soil layers, and the Van Genuchten infiltration parameter. Our results confirm the interest of the robust approach. Indeed, we show that the estimated parameters satisfy a larger set of rain realizations than when compared with the classic calibration of PESHMELBA for the same rain errors.

Short biography (PhD student)

I have completed my master studies in applied mathematics - statistical learning in Politecnico di Milano. My PhD focuses on the calibration of a hydrological model for pesticide transfers, developed to be used as a decision making tool in landscape management, as the latter conditions long-term water quality in rivers surrounded by pesticide-treated agricultural areas. The PhD is co-funded by the research centers INRAE and Inria.

References

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