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Reply on RC1

Vanja Travaš et al.

Author comment on "Estimation of hydraulic conductivity functions in karst regions by particle swarm optimization with application to Lake Vrana, Croatia" by Vanja Travaš et al., Hydrol. Earth Syst. Sci. Discuss., https://doi.org/10.5194/hess-2022-253-AC2, 2023

REMARK: The authors use a system of two ordinary and nonlinear differential equations to describe the exchange of fresh and saltwater between the lake and its surroundings. The method of particle swarm optimization was used to optimize the model. The authors show a complex exercise of the model in the literature.

ANSWER: Thank you for all the constructive comments and remarks. Allow us to address the same below with a few non-pretentious answers.

REMARK: However, the paper does not appear to be significantly innovative.

ANSWER: In order to highlight the scientific significance of the paper, we supplemented the introduction by elaborating the problem of multimodality encountered in such modeling tasks and brought it into relationship with the application of the PSO method and the considered modeling approach by system of ODEs (i.e. lumped karst models). In addition to the mentioned, the list of literature was expanded in order to bring this paper into relationship with previous papers in which the problem of optimization was considered (general optimization and optimization of hydrological models).

As you stated in the review, the model in consideration is represented by a system of two nonlinear ordinary differential equations with variable coefficients (i.e. three calibration functions). Since it cannot be classified as an LTI system, it was to be expected that the task of calibrating such a model would be very complex (note that the calibration functions but also their domains are unknown). The calibration of the model first started with the trial-and-error method, and we immediately established that there is an exceptional sensitivity of the model results to even the smallest changes in the calibration functions. For this reason, we started trying other calibration methods, and of all the ones we tried, the PSO method was convincingly the most effective (due to the multimodality of the problem and the need to perform a global and local search of the target function domain).

This paper was written in order to share our experiences. In this sense, we believe that the modest novelty of the paper can be recognized in the application of the PSO method to the calibration of this type of karst models. Namely, by reviewing the literature, we did not find the same use of the PSO method. Moreover, we came across only a few papers that use the keywords PSO and karst model (but not in the same contest as in this paper).

REMARK: It is suggested that the precipitation recharge should be considered in the model, which could influence the model obviously.

ANSWER: In order to be able to implement appropriate changes or respond to your remarks, we would kindly ask you to clarify the statement "precipitation recharge should be considered". Thank you! We would like to recognize that the precipitation data are included in the groundwater flow component qkl,gw and the surface flow component qkl,sf which was obtained by field measurements (the same as the data of the flow component ql,pr from precipitation on the lake itself). In this way, these terms appear on the RHS as known functions in time and are not the subject of modeling. If the remark meant the model's sensitivity to these parameters, we would ask you to note that this was not the subject of the paper, but we focused on the problem of model calibration. Although we can equip the paper with a shorter sensitivity analysis, we believe that a complete sensitivity analysis would exceed the scope of this paper or would require writing a new paper. On the other hand, if the remark meant the sensitivity of the model with respect to the calibration functions, then we can state that the model result is extremely sensitive to a small change in the calibration functions (which was to be expected due to the nonlinearity of the model – note that the surface flow in Prosika channel is also modeled by not explained in details in the paper). For this very reason, it was necessary to apply the PSO method, which proved to be the best for global and local search of the domain of the objective function. The PSO method was used to search for the best solutions of the calibration functions, which will make the model solution the least sensitive to their change. Since the calibration functions are independent of time (model parameters), the obtained calibrated model represents the basis for further research, among which there will certainly be an analysis of the sensitivity of the model results to precipitations (we believe that this topic should be considered in another separate paper).