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Hydrology and Earth System Sciences
Discussions

# *Interactive comment on* "Technical note: the caRamel R package for Automatic Calibration by Evolutionary Multi Objective Algorithm" *by* Céline Monteil et al.

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General comments and critique

The article presents a recently developed multiobjective calibration algorithm and its implementation in R environment, under the title CaRamel. Its background lies upon two different schemes, i.e. the Multiobjective Evolutionary Annealing Simplex method (MEAS) and the Nondominated Sorting Genetic Algorithm II ($\varepsilon$-NSGA-II). The algorithm is tested against a mathematical problem and a real-world hydrological calibration problem, exhibiting good performance in terms of several metrics.



My overall opinion about this article is positive, yet in its current form cannot stand neither as a technical note not as research paper. Actually, it rather resembles to an extended abstract of a clearly hard and long research, which may be useful as a brief documentation for the R community, but is not suitable for a top hydrological journal such as HESS. First of all, the authors have to decide the orientation and the objectives of this article. There are several alternatives, i.e. (a) a state-of-the-art discussion of the multiobjective calibration problem in hydrology; (b) a comprehensive description and justification of the algorithm and its technological advances, accompanied by extended tests of its performance against problems of varying complexity and against other well-established methodologies, and (c) a more synoptic description of the algorithm, with emphasis to its application to few (not only one) representative hydrological calibration problems of varying difficulty, to be presented and discussed in detail.

In this context my recommendation is for a major revision, towards the formulation of a substantially enhanced research paper (not a technical note).

Specific comments

Page 1, lines 13-14: "The main function of the package, caRamel(), requires to define a multi-objective calibration function as well as bounds on the variation of the underlying parameters to optimize". Too obvious technical detail to be referred in the abstract.

Page 1, lines 24-25: ". . . it is well-know that errors in a simulated discharge time series are not normally distributed, and do not have constant variance and autocorrelation." This statement is true (a reference would be helpful, e.g. Sorooshian and Dracup, 1980), but is not so much evidently linked with the need for multiobjective calibration. Actually, the multiobjective approach in hydrological modelling covers much more cases, including fitting to multivariable and multisite data, as well as soft information (cf., Madsen, 2003; Efstratiadis Koutsoyiannis, 2010).

Page 1, lines 28-29: "Evolutionary algorithms have become widely used to explore the Pareto-optimal front in multi-objective optimization problems that are too complex

to be solved by descent methods". Do they exist descent methods for multiobjective optimization? Maybe you refer to classical aggregation approaches (e.g. weighting of criteria) that have to be solved multiple times with different weighting values, in contrast to evolutionary approaches that only require "a single optimization run", as correctly mentioned just after (page 2, line 2).

Page 2, lines 5-6: "The caRamel optimizer has been developed to meet the need of an automatic calibration procedure that delivers not only one but a family of parameters sets that are optimal regarding a multi-objective target". There do exist many algorithms covering this general objective. Is there any specific objective for the development of caRamel? Which shortcomings of the existing algorithms have you detected before deciding building a new method?

Page 2, line 17: Terms "flood objective" and "low flow objective" are unclear (at least for a non-expert). Page 2, lines 17-19: "Multi-objective calibration is also a way to add some constraints to an underconstrained problem when many parameters have to be quantified. This can help to reduce the equifinality of parameters sets". More discussion should be made here (for 30 years, equifinality remains a hot topic in hydrology), including some representative references, e.g. Her and Seong (2018).

Page 2, lines 20-21: "Equifinality may be caused by the model structure, when two sets of parameters give similar results. Another kind of equifinality is related to the calibration objectives, when two different model results give similar objective values." Term "result" is unclear – probably you refer to the model outputs, by means of response time series. In this respect, two different parameter sets, except if they are very close, cannot provide the same outputs (i.e., similar individual values), they can provide outputs with similar statistical characteristics, and thus similar performance metrics, as correctly stated in the second phrase.

Page 2, line 28: Please, also cite the more detailed and peer-reviewed paper by Efstratiadis and Koutsoyiannis (2008), published as book chapter.



Page 3, section 2.1.1 (Generation rules): The description of the algorithm is very poor and only provides a very general idea about the generation mechanisms. How are these rules associated with the ones used in MEAS? I see quite many differences and very interesting ideas implemented here, but the text is too short to allow understanding and evaluating the methodology (and its potential novelties). Figure 1 is also little helpful; for instance, green and blue points, indicating new sets, are missing, although they are referred in the legend.

Page 3, line 25: Why you keep points of the lower level? Aren't they dominated by points of the upper one?

Pages 4-5, section 2.2 (The caRamel R package): This section is very technical and not so much relevant with the broader philosophy of HESS.

Page 5, line 15: "The diversity which can be described with two aspects: the spread of the set . . ." Diversity may refer both to the parameter and the objective space. Which of the two sets are used here?

Page 5, line 25: Please, cite Deb et al. (2002) who developed NSGA-II.

Page 6, lines 12-13: "Comparison with MCO (NSGA-II only) shows that the use of MEAS makes the optimization process converge more rapidly but with a lower diversity". Can you explain the reason of this behavior? Is this an inherent drawback of caRamel, or is due to the algorithmic inputs used in this experiment? As shown in Table 1 (and similarly to all hybrid optimization schemes), caRamel uses quite a large number of input arguments that need manual tuning. Did you run the algorithm by testing alternative set-ups? Do you have any recommendations for the users, regarding the selection of these inputs?

Page 7, section 4.2 (Hydrological modeling): Your case study does not allow extracting safe conclusions about the performance of your method and its comparison against NSGA II. The key reason is that the use of a single overall metric, i.e. KGE, ensures

almost perfect fitting to observations (KGE = 95

Page 8, line 8: Please, better explain criteria (2) and (3) and the associated signatures. Have been these criteria used elsewhere? If yes, please also provide the associated references.

Page 9, lines 3-4: “MCO has been used with crossover probability set to 0.5 and mutation probability to 0.3”. Have you made any preliminary tests before selective these values? Which are the values applied to the input arguments of caRamel?

Page 9, Figure 5: I find your figure a little bit misleading. In the vertical axis, the spread of solutions is very small, and within the anticipated range of uncertainty induced in any hydrological calibration exercise. For instance, the lower value of KGEamd is 0.83, while the higher is 0.86. From my point-of-view, such differences do not make sense in the real world.

Page 10, line 12: How did you selected the best compromise parameter set? What do you mean by term “observed set”?

Page 11, section 5 (Conclusions): This section is poorly developed. It has to be written from scratch, to highlight the advantages and weaknesses of the methodology and also discuss ideas for future research.

Minor editorial comments

Page 2, line 10: In which of the aforementioned papers do you describe the algorithm? It is not clear here.

Page 2, line 17: Term “Hydrology” should not start with capital.

Page 2, line 18: Please, change “underconstrained” to read “unconstrained”.

Page 3, line 3: Please, change to read “with respect to”.

Page 8, line 16: Please, change to read “parameter sets”.



Page 9, line 7: Please, change to read “Pareto fronts”.

Page 9, lines 16-17: Please, change to read “The GS metric exhibits a larger variability, thus a larger envelope for both optimizers”.

References

Deb, K., Pratap, A., Agarwal, S. Meyarivan, T.: A fast and elitist multiobjective genetic algorithm: NSGA-II. IEEE Trans. Evol. Comput., 6(2), 182-197, 2002.

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