

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

**Guillaume Thirel (Referee)**

guillaume.thirel@irstea.fr

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This manuscript presents an R package useful for calibrating hydrological models against a multi-objective function. It is submitted as a technical note in HESS and as a consequence remains rather short.

The topic of R packages that are dedicated to hydrology is relevant to HESS, as demonstrated the very recent review paper by Slater et al. (2019) in which I participated. I think that this paper should be mentioned in the manuscript, not because I co-authored it, but because it justifies the interest of such packages to the hydrological community. Indeed, a basic search for the word “package” in the titles or abstracts of HESS papers

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does not provide so many results. . .

I understand from discussions between the editor and the authors (not available online) that a first version was submitted to another journal and it was suggested to focus more on the package than on actual comparison of algorithms impacts. That can be true for model-oriented journals, such as EM&S and GMD (see for instance our airGR paper in EM&S, Coron et al., 2017, which was a Short Communication). However in my opinion HESS is different: describing software and providing pieces of codes is very much appreciate (for the sake of reproducibility), but we also need science. Simply describing packages or tools is not the main aim of HESS. Here the science is a new calibration algorithm and its impact. As a consequence, more emphasis should be put on that two points, but the Editor Elena Toth already commented on that and I agree with her. In the end, I'm wondering if this paper will remain a Technical note or become a full research article.

Overall, the paper is good, it is of interest for the HESS readers in my opinion, and provided that the objectives of the paper are modified as mentioned below and above, I am confident that it will be published later on.

Main criticism:

My main criticism regards the fact that the authors submitted a manuscript into an open journal, for presenting an open source software, but they illustrate it with an hydrological model that is not open! While I know that MORDOR is the historical EDF hydrological model and using the MORDOR model with caRamel makes sense for the authors, this in my opinion is much less obvious for the readers. I guess that the aim of the authors is to make readers understand that caramel is a valuable tool for calibrating hydrological models available in R. However, no mention is ever made of the fact that there are hydrological models available in the R environment, justifying the interest of this new package. Indeed, readers cannot manipulate the MORDOR model, they only have brief knowledge of the parameters meaning from this paper and they cannot run

the lines of codes provided by the authors to handle the package. I think that this is a pity, as the authors made a laudable effort to provide an open source software, some vignettes and also some lines of codes. In addition to the fact that the model is not available, no example data are provided. All of this does not prevent from using the package, but I find it damageable to stop so close to total openness. As one of the developers of the airGR R package, as you know, I tested the caRamel algorithm with a simple GR4J model and an example dataset included in the airGR package. It is not difficult to make it work, but from what was provided it is not straightforward (I guess that the fact that I know well my package helped, but for people using caRamel with a package they did not develop it could be more difficult). I provide the lines of codes I wrote at the end of this review. I would therefore suggest to the authors to include a full example, i.e. one that could be reproduced by the readers, with one open (and well-known if possible!) hydrological model and one open dataset. I don't think this is much work and I don't think that would deeply impact the paper, but I feel that would be useful. Of course, as I provide some lines of codes in this review (see the figures 1, 2, 3, as well as the supplement for the R file) and as some authors know well the GR models, airGR would be a straightforward solution, but as highlighted in Slater et al. (2019) (see section 3.5), other well-known hydrological models are openly available in other R packages.

Major remarks:

Introduction: nothing is said about composite criteria (e.g. an average of KGEs). I think it should be mentioned and discussed on the base of a couple of references. That's what I tested in the code I provided and the results in terms of performance are quite similar to the multi-objective calibration with the same objectives. This is also much faster, but I guess that the choice of the convergence threshold of caRamel is important in this example.

Heterogeneous spelling in the text: see for instance "Multi Objective" in the title, "multi-objective" and "multiobjective" in the abstract. Or "modelling is the abstract but "mod-

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elling” in L. 2, P. 2. “R package” in the title and “R-package” in L. 8, P. 2. “Pareto-front” in P. 5, L. 14 and “Pareto front” in P. 5, L. 28, “Pareto Front” in P. 9, L. 12. Please try to be consistent all over the manuscript! I did not spot all of them here.

About section 2.1.1, which describes the generation of parameters. I had difficulties to understand the complete functioning of the 5 rules. First, are these 5 rules or in fact 5 steps that are undertaken successively? In addition, a figure is presented for the first two steps, but it is not used efficiently to make things clear for the readers. I have the feeling that this could be improved easily. For example, why not using only 2 parameters instead of 3, as 3D plots are not possible here? That would simplify things. There are also terms in the legend that are not explained, such as “Example” or “Simplexes”. Since the figure is quite complex, with many points, triangles, arrow, it is necessary to help us to read it. I would also maybe suggest a concrete example somehow, especially about the evolution of the parameters sets number, as it is stated at L. 20 that it is necessary to reduce the number of sets. Maybe specify that no parameter set is discarded during the 5 rules stuff?

Section 2.1.2: quite similarly to the previous section, I find that Fig. 2 is underexploited / underexplained. Levels 2 and 3 are never referred to either in the text or in the caption.

Section 4.1: Results are presented for the Kursawe function in Fig. 3. Here again some improvement is possible that would help our reading. What is the optimum for the two objectives? Caption: MCO is not mentioned regarding the number of evaluations; is it 1000? Or does that mean that Fig. 3a only concerns caRamel? If so, why? (I guess this is the case from the reading of the text, but then the caption could be improved). We could have a similar graph for mco.

Section 4.2.4: Figure 5 is quite difficult to read, in the sense that there are too many points and the superposition of the two algorithms results does not permit to see the differences. Maybe you should separate the two algorithms in two different graphs for each panel? In addition, we don't know from which algorithm are chosen the red points,

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if I'm not wrong.

Regarding the name of the package, I recommend, if you use LaTeX, to use the `\texttt` font. This is what we did in Slater et al. (2019) and I think it helps the reading a lot. In addition, it helps making the distinction between the package and the main function, which have the exact same name. We also adopted the spelling "R package" instead of "R-package".

Section 3: I would like to have access to the equations of the metrics, as these are not common metrics used by hydrologists.

References:

- Efstratiadis and Koutsoyiannis: this is a conference abstract. What do you think about citing their HSJ paper entitled "One decade of multi-objective calibration approaches in hydrological modelling: A review"?
- Garavaglia et al. : this paper has been published in 2017, please update.
- Le Moine 2009: I think we need a link towards the pdf of this report.
- Monteil et al.: any paper or accessible report or presentation instead of this EGU abstract?
- Riquelme et al.: Conférence is written in French

Minor typos and miscellaneous minor stuff:

I found a bunch of very minor typos that could easily be dealt with by the authors. As a non-native speaker myself, I hope I'm correct when suggesting these modifications and also that I'm not too picky... I also do not guarantee that I spotted all of them!

Page 1:

L. 12: remove "algorithm" after NSGA-II as the A of NSGA stands for "algorithm"

L. 20: The first sentence of the introduction is the same as the first one of the abstract,

except for the word “calibration” that is replaced with “prescription”. I personally prefer “calibration”.

L. 22: I would add a comma after “precisely”

L. 23: not 100% sure, but I think that here “statistic” should be spelt “statistics”

L. 24: “well-knowN”

Page 2:

L. 7-8: please revise the format of citations (i.e. add commas around the years). In addition, I think that the citations should be ordered either by alphabetical or by chronological order.

L. 8: as I guess this is the case for all citations, I would rephrase the parenthesis as follows: “all previously to the release of the R package”

L. 9: “of THE caramel algorithm”

L. 11: I would say “simply has” instead of “has simply”

L. 17: as it is an adjective to the word “objective”, I think that “low-flow” is more correct. At this line and all other occurrences, I would remove the capital letter to “hydrology”.

L. 22: either “one additional objective” or “additional objectiveS”. “Constrain”, not “constraint”.

L. 24: “THE caRamel algorithm belongs to THE. . .”

L. 26: “THE caRamel. . .”

Page 3:

L. 2: I would say “The caRamel algorithm”

L. 16: “fRont”

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L. 20: “each generation”: does each of the 5 rules counts for one generation?

Page 4:

L. 6: “this syntax”. In addition, please remove the space after “caRamel” and before the parenthesis.

L. 9-10 “the minimization or maximization goal”: from the way it is written, I was expecting a value. Actually, it is a Boolean used for saying if this is a maximization (minmax = TRUE) or not. I would suggest rephrasing. In addition, I think that the name of the argument, minmax, is not well chosen. minmax is ok if the choices are “min” and “max”, but not if the choices are “TRUE” or “FALSE”.

L. 15: I would say “choice of a parallel or sequential computation”

L. 18: not clear. Which kind of managing?

L. 19: there are six elements when I tried it, but the last one (gpp) is not explained in the package.

L. 23: I would say “of objective values”, as otherwise we don’t know if these are names or values.

Page 5:

L. 6: “an R vignette that gives”

L. 14, 15, 17: I would add a comma after accuracy, diversity, cardinality.

L. 20: please add “, which” after “(GS)”

L. 21: please add a comma after “(HV)” and an hyphen in “volume-based”

L. 24: I would rather say “the R package `\texttt{mco}` (“Multiple Criteria Optimization”, Mersmann et al., 2014)”. Please also make sure in the whole manuscript that the package name is written as `mco`, not `MCO`.

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Page 6:

L. 2: “with THE Kursawe...”. In addition, I think it is necessary to introduce a bit what this function, is, what is its aim. I’m not familiar with it and I guess that some other hydrologists also are not.

L. 4: “THE population size”

L. 5 and 8: “THE caRamel ...”

L. 10: double typo: “show that caRamel”

Page 7:

L. 11: maybe specify on which spatial unit the model is semi-distributed.

Page 8:

L. 2 then is the snow part of the model active?

L. 8: define the KGE acronym.

L. 10: maybe replace “is the result of” with “reflects”

L. 16: here and everywhere else, I would write “parameter sets” with no S at parameter.

Page 9:

L. 4: “In the mco. ...”

L. 17: “optimizerS” and “getS”

L. 18-19: what is the meaning of reproducible? I don’t get it.

Page 10:

L. 4: “provide”, not “provides”

L. 5: “give”, not “giving”

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L. 6: I quite disagree regarding the “cel” parameter as especially for mco, the spread seems quite large on Fig. 7.

L. 13: any idea about how many parameter sets that represents?

Page 11:

L. 10: “in an R...”

L. 11: “THE result”

L. 14: “from THE mco R package...”

L. 18: “provided that”

L. 21: “as an R package”

Appendix A and B:

In the code, some spaces are randomly put before or after commas. That could be clean.

Table 1: caption: “of THE caRamel...”

I have a couple of comments regarding the description of the main function of the package:

- nvar: why not using the word parameter instead of variable? See the description of argument bounds, which uses the name “parameter”
- minmax: somehow it should appear that several values are possible (e.g. “whether the objectives are...”)
- func: “the R objective function”
- objnames: “nameS”
- write\_gen: that would be much more logical to have a logical here instead of an

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integer

- func and funcinit: these two arguments do not take characters but functions. If we enter “kursawe” it does not work, we have to put the name of the function. See FUN argument of tapply for instance.

Table 2: cetp is a “multiplicative” correction factor

References:

Coron, L., Thirel, G., Delaigue, O., Perrin, C., Andréassian, V., 2017: The Suite of Lumped GR Hydrological Models in an R package, *Environmental Modelling & Software*, 94, 166-171, DOI: 10.1016/j.envsoft.2017.05.002.

Slater, L. J., Thirel, G., Harrigan, S., Delaigue, O., Hurley, A., Khouakhi, A., Prodocimi, I., Vitolo, C., and Smith, K.: Using R in hydrology: a review of recent developments and future directions, *Hydrol. Earth Syst. Sci.*, 23, 2939-2963, <https://doi.org/10.5194/hess-23-2939-2019>, 2019.

Please also note the supplement to this comment:

<https://www.hydrol-earth-syst-sci-discuss.net/hess-2019-259/hess-2019-259-RC1-supplement.zip>

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Interactive comment on *Hydrol. Earth Syst. Sci. Discuss.*, <https://doi.org/10.5194/hess-2019-259>, 2019.

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```
##### test GR #####
rm(list = ls())
library(airGR)
library(caRamel)

## loading catchment data
data(L0123001)

## preparation of the InputsModel object
InputsModel <- CreateInputsModel(FUN_MOD = RunModel_GR4J, DatesR = BasinObs$DatesR,
                                 Precip = BasinObs$P, PotEvap = BasinObs$E)

## run period selection
Ind_Run <- seq(which(format(BasinObs$DatesR, format = "%Y-%m-%d")=="1990-01-01"),
               which(format(BasinObs$DatesR, format = "%Y-%m-%d")=="1999-12-31"))

## preparation of the RunOptions object
RunOptions <- CreateRunOptions(FUN_MOD = RunModel_GR4J,
                               InputsModel = InputsModel, IndPeriod_Run = Ind_Run)

## single efficiency criterion: KGE
InputsCrit <- CreateInputsCrit(FUN_CRIT = ErrorCrit_KGE,
                              InputsModel = InputsModel, RunOptions = RunOptions,
                              Obs = list(BasinObs$Qmm[Ind_Run]),
                              VarObs = "Q", transfo = "",
                              Weights = NULL)

## single efficiency criterion: KGE sqrt
InputsCrit2 <- CreateInputsCrit(FUN_CRIT = ErrorCrit_KGE,
                               InputsModel = InputsModel, RunOptions = RunOptions,
                               Obs = list(BasinObs$Qmm[Ind_Run]),
                               VarObs = "Q", transfo = "sqrt",
                               Weights = NULL)

InitGR<-function(cl,numcores){
  parLapply( cl, 1:numcores, function(xx){require('airGR'))})
  clusterExport(cl=cl, varlist=c("InputsModel", "RunOptions", "InputsCrit", "InputsCrit2"))
}

EvalGR <- function(i){## Transformation of the parameter set to real space
  RawParamOptim <- airGR::TransfoParam_GR4J(ParamIn = x[i,],
                                           Direction = "TR")

  ## Simulation given a parameter set
  OutputsModel <- airGR::RunModel_GR4J(InputsModel = InputsModel,
                                       RunOptions = RunOptions,
                                       Param = RawParamOptim)

  ## Computation of the value of the performance criteria
  OutputsCrit <- airGR::ErrorCrit_KGE(InputsCrit = InputsCrit,
                                     OutputsModel = OutputsModel,
                                     verbose = FALSE)

  ## Computation of the value of the performance criteria
  OutputsCrit2 <- airGR::ErrorCrit_KGE(InputsCrit = InputsCrit2,
                                       OutputsModel = OutputsModel,
                                       verbose = FALSE)

  return(c(OutputsCrit$CritValue, OutputsCrit2$CritValue) )
}

# definition of the bounds of parameters (between -9.99 and 9.99)
# the parameter values will be transformed to actual parameter values in EvalGR
bounds <- matrix(c(rep(-9.99, 4),rep(9.99, 4)), ncol = 2)
```

Fig. 1.

```

results <- caRamel(nobj = 2, nvar = 4, minmax = rep(TRUE,2), bounds = bounds, func = EvalGR,
  funcinit = InitGR, popsize = 100, archsize = 100, maxrun = 15000,
  prec = rep(1.e-4,2) )

Param_temp <- results$parameters[round(dim(results$parameters)[1]/2),] #choosing a kind of median parameter set
Param <- airGR::TransfoParam_GR4J(ParamIn = Param_temp, Direction = "TR") # transforming back to actual parameter values
## Simulation given the optimised parameter set
OutputsModel <- airGR::RunModel_GR4J(InputsModel = InputsModel,
  RunOptions = RunOptions,
  Param = Param)

## Computation of the value of the performance criteria
OutputsCrit <- airGR::ErrorCrit_KGE(InputsCrit = InputsCrit,
  OutputsModel = OutputsModel,
  verbose = FALSE)## Computation of the value of the performance criteria
OutputsCrit2 <- airGR::ErrorCrit_KGE(InputsCrit = InputsCrit2,
  OutputsModel = OutputsModel,
  verbose = FALSE)
print(c(OutputsCrit$CritValue, OutputsCrit2$CritValue))

##### comparison the airGR calibration (Calibration_Michel) and a composite OF #####

rm(list = ls())
library(airGR)

## loading catchment data
data(L0123001)

## preparation of the InputsModel object
InputsModel <- CreateInputsModel(FUN_MOD = RunModel_GR4J, DatesR = BasinObs$DatesR,
  Precip = BasinObs$P, PotEvap = BasinObs$E)

## run period selection
Ind_Run <- seq(which(format(BasinObs$DatesR, format = "%Y-%m-%d")=="1990-01-01"),
  which(format(BasinObs$DatesR, format = "%Y-%m-%d")=="1999-12-31"))

## preparation of the RunOptions object
RunOptions <- CreateRunOptions(FUN_MOD = RunModel_GR4J,
  InputsModel = InputsModel, IndPeriod_Run = Ind_Run)

## efficiency composite criterion: KGE mixing
## both raw and sqrt-transformed flows
InputsCritCompo <- CreateInputsCrit(FUN_CRIT = list(ErrorCrit_KGE, ErrorCrit_KGE),
  InputsModel = InputsModel, RunOptions = RunOptions,
  Obs = list(BasinObs$Qmm[Ind_Run], BasinObs$Qmm[Ind_Run]),
  VarObs = list("Q", "Q"), transfo = list("", "sqrt"),
  Weights = list(0.5, 0.5))

## preparation of CalibOptions object
CalibOptions <- CreateCalibOptions(FUN_MOD = RunModel_GR4J, FUN_CALIB = Calibration_Michel)

## calibration
start time <- Sys.time()

```

Fig. 2.

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```

OutputsCalib <- Calibration_Michel(InputsModel = InputsModel, RunOptions = RunOptions,
                                  InputsCrit = InputsCritCompo, CalibOptions = CalibOptions,
                                  FUN_MOD = RunModel_GR4J)

end_time <- Sys.time()
end_time - start_time

## simulation
Param <- OutputsCalib$ParamFinalR
OutputsModel <- RunModel_GR4J(InputsModel = InputsModel,
                               RunOptions = RunOptions, Param = Param)

## Computation of the value of the performance criteria
## single efficiency criterion: KGE
InputsCrit <- CreateInputsCrit(FUN_CRIT = ErrorCrit_KGE,
                              InputsModel = InputsModel, RunOptions = RunOptions,
                              Obs = list(BasinObs$Qmm[Ind_Run]),
                              VarObs = "Q", transfo = "",
                              Weights = NULL)

## single efficiency criterion: KGE sqrt
InputsCrit2 <- CreateInputsCrit(FUN_CRIT = ErrorCrit_KGE,
                              InputsModel = InputsModel, RunOptions = RunOptions,
                              Obs = list(BasinObs$Qmm[Ind_Run]),
                              VarObs = "Q", transfo = "sqrt",
                              Weights = NULL)

OutputsCrit <- airGR::ErrorCrit_KGE(InputsCrit = InputsCrit,
                                   OutputsModel = OutputsModel,
                                   verbose = FALSE)## Computation of the value of the performance criteria
OutputsCrit2 <- airGR::ErrorCrit_KGE(InputsCrit = InputsCrit2,
                                   OutputsModel = OutputsModel,
                                   verbose = FALSE)

print(c(OutputsCrit$CritValue, OutputsCrit2$CritValue))

```

Fig. 3.

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