Latest developments of the airGR rainfall-runoff modelling R package: new calibration procedures and other features

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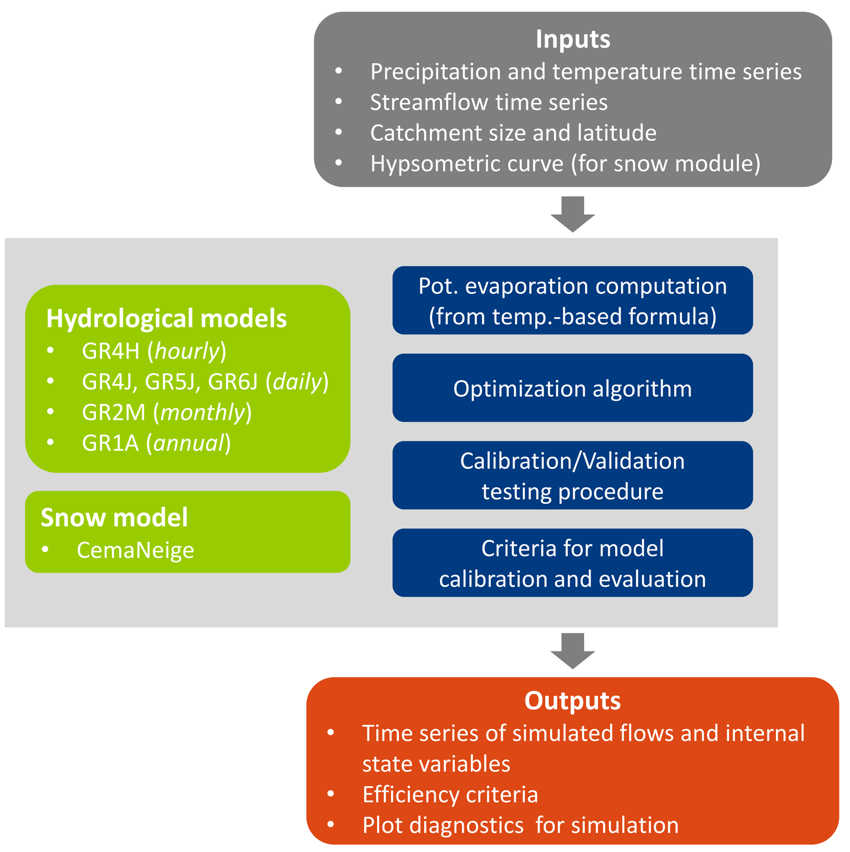
GR is a family of lumped hydrological models designed for flow simulation at various time steps. The models are freely available in an R package called airGR (Coron *et al.*, 2017a, 2017b). The models can easily be implemented on a set of catchments with limited data requirements.

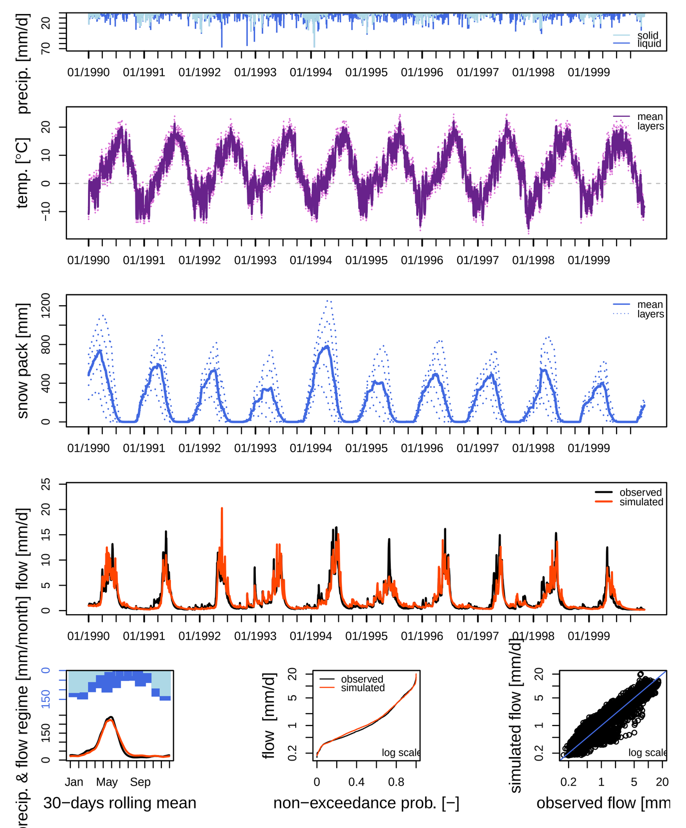
GR hydrological models

- Designed with the objective to be as efficient as possible for flow simulation at various time steps (from hourly to interannual)
- Warranted complexity structures and limited data requirements
- Can be applied on a wide range of conditions, including snowy catchments (CemaNeige snow routine included)

Main components of the airGR package



Plot diagnostics example (GR4J + CemaNeige)



News since EGU 2017 – airGR 1.0.9.64 vs airGR 1.0.5.12

- The `Param_Sets_GR4J` dataset was added. It contains generalist parameter sets for the GR4J model
  - If the calibration period is too short (< 6 months) and by consequence non representative of the catchment behaviour, a local calibration algorithm can give poor results and we recommend to use the generalist parameter sets instead
- Vignettes were added. They explain how to perform parameters estimation with:
  - Differential Evolution calibration algorithm
  - Particle Swarm calibration algorithm
  - MA-LS-Chains calibration algorithm
  - Bayesian MCMC framework
- A new airGRteaching package (Delaigue *et al.*, 2018) provides tools to simplify the use of the airGR hydrological package for education, including a 'Shiny' interface

Future developments

- New version of CemaNeige that allows to use satellite snow cover area for calibration (Riboust *et al.*, accepted)
- Parameters maps on France for GR4J, GR5J & GR6J models for ungauged bassins (Poncelet *et al.*, submitted)

How to use other R packages to perform parameters estimation

- Definition of the necessary function:
  - transformation of parameters to real space (available in airGR)
  - computation of the value of the performance criterion (e.g. RMSE)

```
OptimGR4J <- function(Param_Optim) {
  Param_Optim_Vre <- airGR::TransfoParam_GR4J(ParamIn = Param_Optim,
                                              Direction = "TR")
  OutputsModel <- airGR::RunModel_GR4J(InputsModel = InputsModel,
                                       RunOptions = RunOptions,
                                       Param = Param_Optim_Vre)
  OutputsCrit <- airGR::ErrorCrit_RMSE(InputsCrit = InputsCrit,
                                       OutputsModel = OutputsModel)
  return(OutputsCrit$CritValue)
}
```

- Definition of the lower and upper bounds of the four GR4J parameters in the transformed parameter space

```
lowerGR4J <- rep(-9.99, times = 4)
upperGR4J <- rep(+9.99, times = 4)
```

- Local optimisation
  - Single-start (here) or multi-start approach to test the consistency of the local optimisation

```
startGR4J <- c(4.1, 3.9, -0.9, -8.7)
optPORT <- stats::nlminb(start = startGR4J, objective = OptimGR4J,
                         lower = lowerGR4J, upper = upperGR4J,
                         control = list(trace = 1))
```

- Global optimisation
  Most often used when facing a complex response surface, with multiple local mimina
  - Differential Evolution

```
optDE <- DEoptim::DEoptim(fn = OptimGR4J,
                          lower = lowerGR4J, upper = upperGR4J,
                          control = DEoptim::DEoptim.control(NP = 40, trace = 10))
```

  - Particle Swarm

```
optPSO <- hydroPSO::hydroPSO(fn = OptimGR4J,
                             lower = lowerGR4J, upper = upperGR4J,
```

  - MA-LS-Chains

```
optMALS <- Rmalschains::malschains(fn = OptimGR4J, maxEvals = 2000,
                                   lower = lowerGR4J, upper = upperGR4J)
```

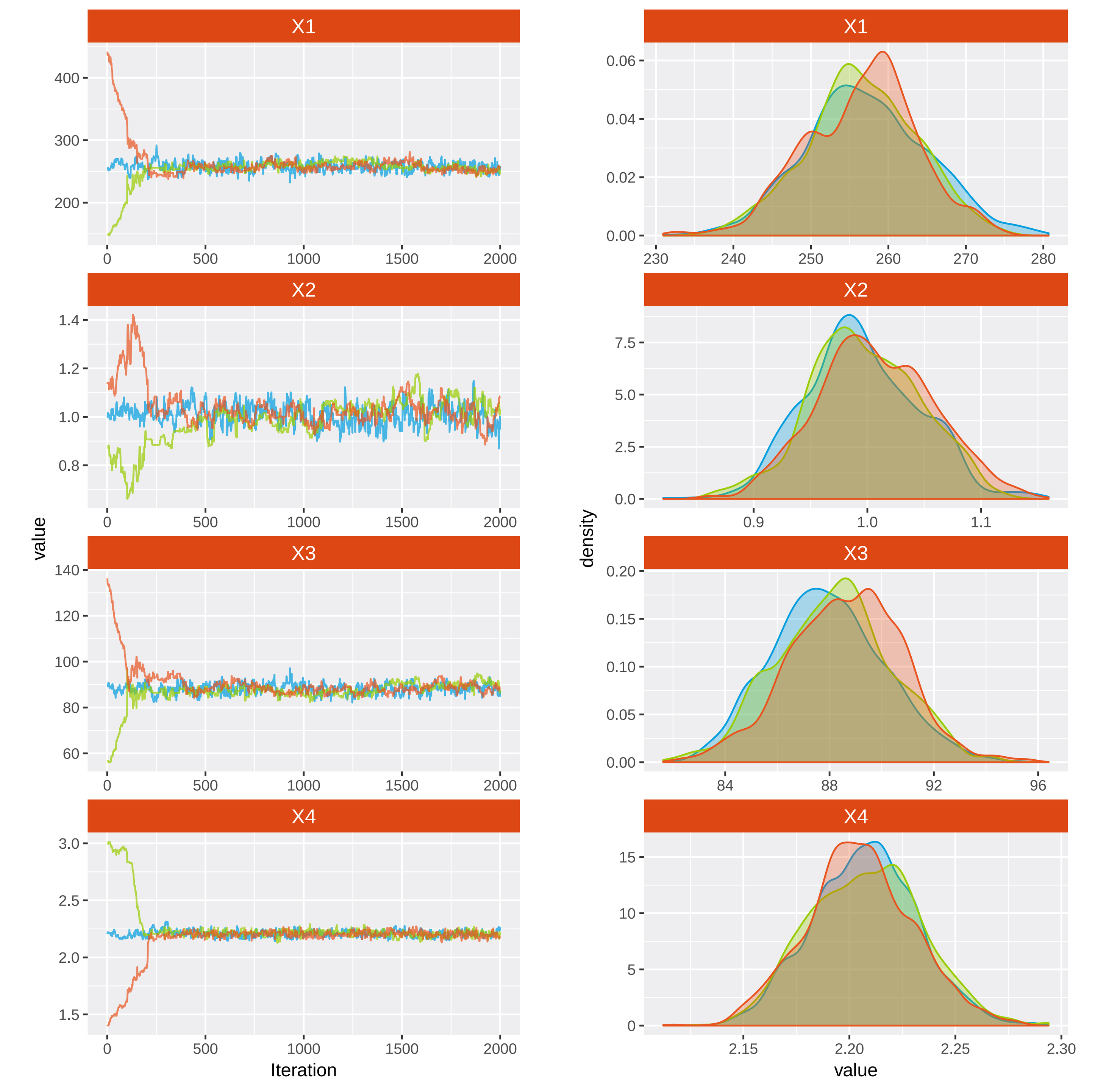
- Results

Algo	X1	X2	X3	X4	RMSE	CPU
airGR	257.238	1.012	88.235	2.208	0.7852	00.53 s
PORT	256.808	1.004	88.167	2.205	0.7852	01.79 s
DE	256.808	1.004	88.167	2.205	0.7852	75.10 s
PSO	256.836	1.006	88.207	2.204	0.7852	29.55 s
MA-LS	256.808	1.004	88.167	2.205	0.7852	18.42 s

Download the airGR package

The airGR package is available on the Comprehensive R Archive Network:
`https://CRAN.R-project.org/package=airGR/`

Evolution of 3 Markov chains & posterior density for each parameter



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