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

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► To cite this version:

Olivier Delaigue, Guillaume Thirel, François Bourgin, Laurent Coron. Latest developments of the airGR rainfall-runoff modelling R package: new calibration procedures and other features. EGU General Assembly 2018, Apr 2018, Vienna, Austria. hal-02607857

HAL Id: hal-02607857

<https://hal.inrae.fr/hal-02607857v1>

Submitted on 16 May 2020

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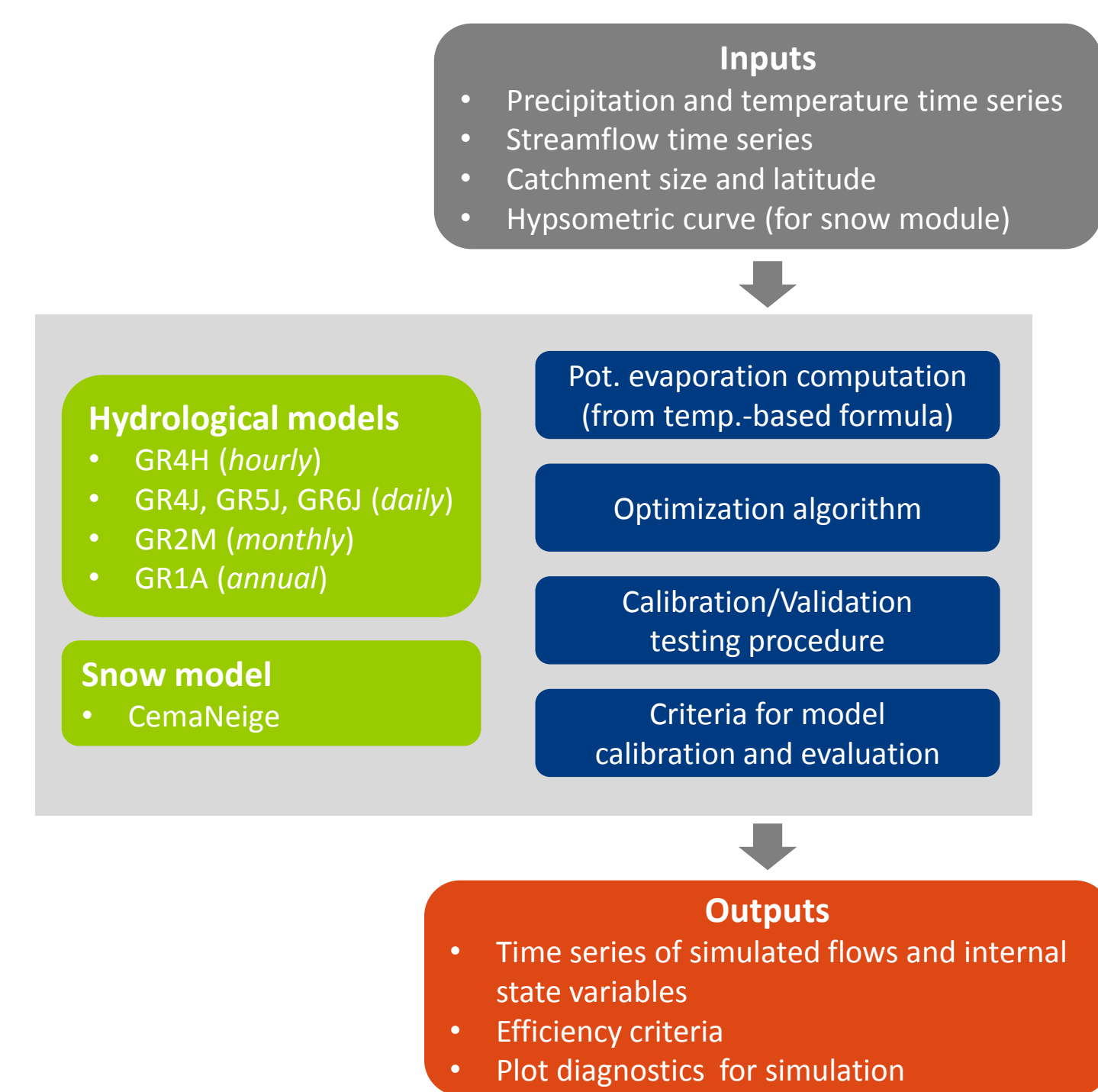
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GR is a family of lumped hydrological models designed for flow simulation at various time steps. The models are freely available in an R package called airGR (Coron *et al.*, 2017a, 2017b). The models can easily be implemented on a set of catchments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

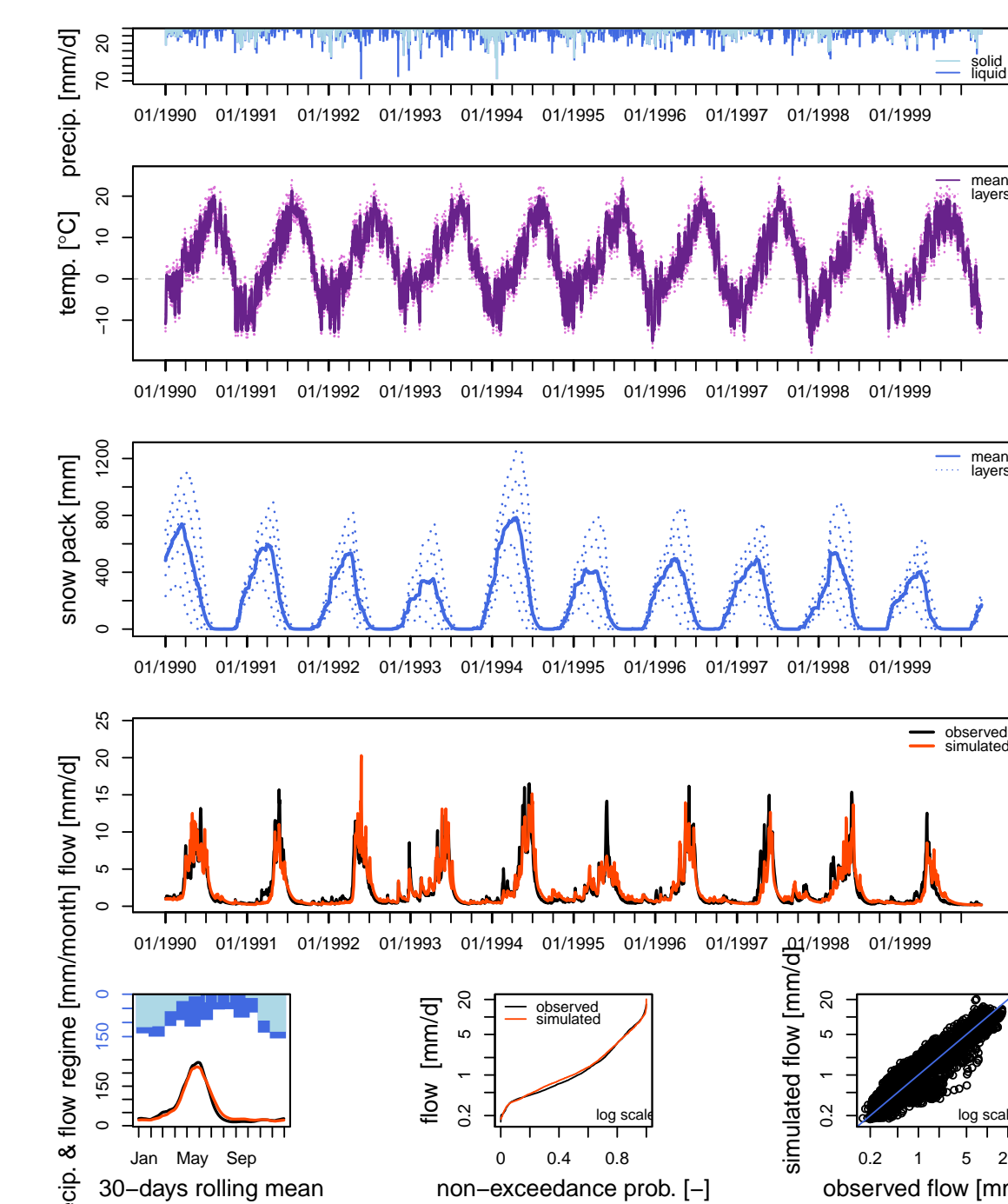
GR hydrological models

- ▶ 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 basins (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 minima
 - ▶ 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

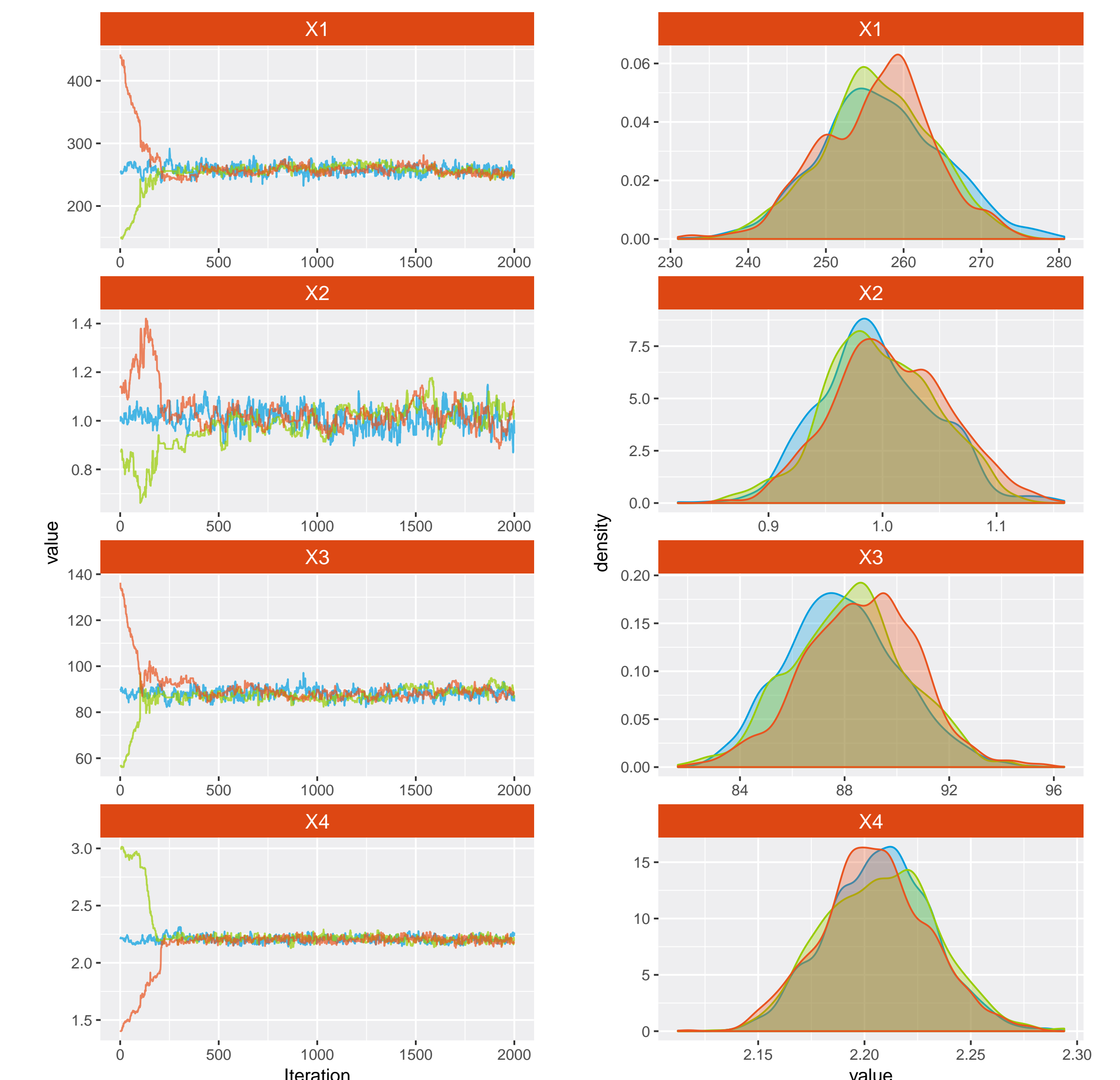

```
optMALS <- Rmalschains::malschains(fn = OptimGR4J, maxEvals = 2000,
                                   lower = lowerGR4J, upper = upperGR4J)
```
- ▶ Results

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



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.
- ▶ Coron L., Perrin C., Delaigue, O., Thirel, G. & Michel C. (2017). airGR: Suite of GR Hydrological Models for Precipitation-Runoff Modelling. R package version 1.0.9.64. URL: <https://webgr.irstea.fr/en/airGR/>.
- ▶ Delaigue, O., Coron, L. & Brigode, P. (2018). airGRteaching: Teaching Hydrological Modelling with the GR Rainfall-Runoff Models ('Shiny' Interface Included). R package version 0.2.2.2. URL: <https://webgr.irstea.fr/en/airGR/>.
- ▶ Poncelet, C., Andréassian, V., & Oudin, L. (submitter). Regionalization of Hydrological Models by Group Calibration. *Water Resources Research*.
- ▶ Riboust, P., Thirel, G., Le Moine, N. & Ribstein, P. (accepted). Revisiting a simple degree-day model for integrating satellite data: implementation of SWE-SCA hystereses. *Journal of Hydrology and Hydrodynamics*, DOI: 10.2478/johh-2018-0004.