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# airGR & airGRteaching: two packages for rainfall-runoff modeling and teaching hydrology

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The use of R is growing fast in hydrology, as it covers all the steps necessary to lead complete hydrological studies (Slater *et al.*, 2019). GR is a suite of lumped hydrological models designed for flow simulation at various time steps. The models are available in the airGR package and can easily be implemented on a set of catchments with limited data requirements. airGRteaching is an add-on to airGR which simplifies its use and is more specifically oriented towards teaching.

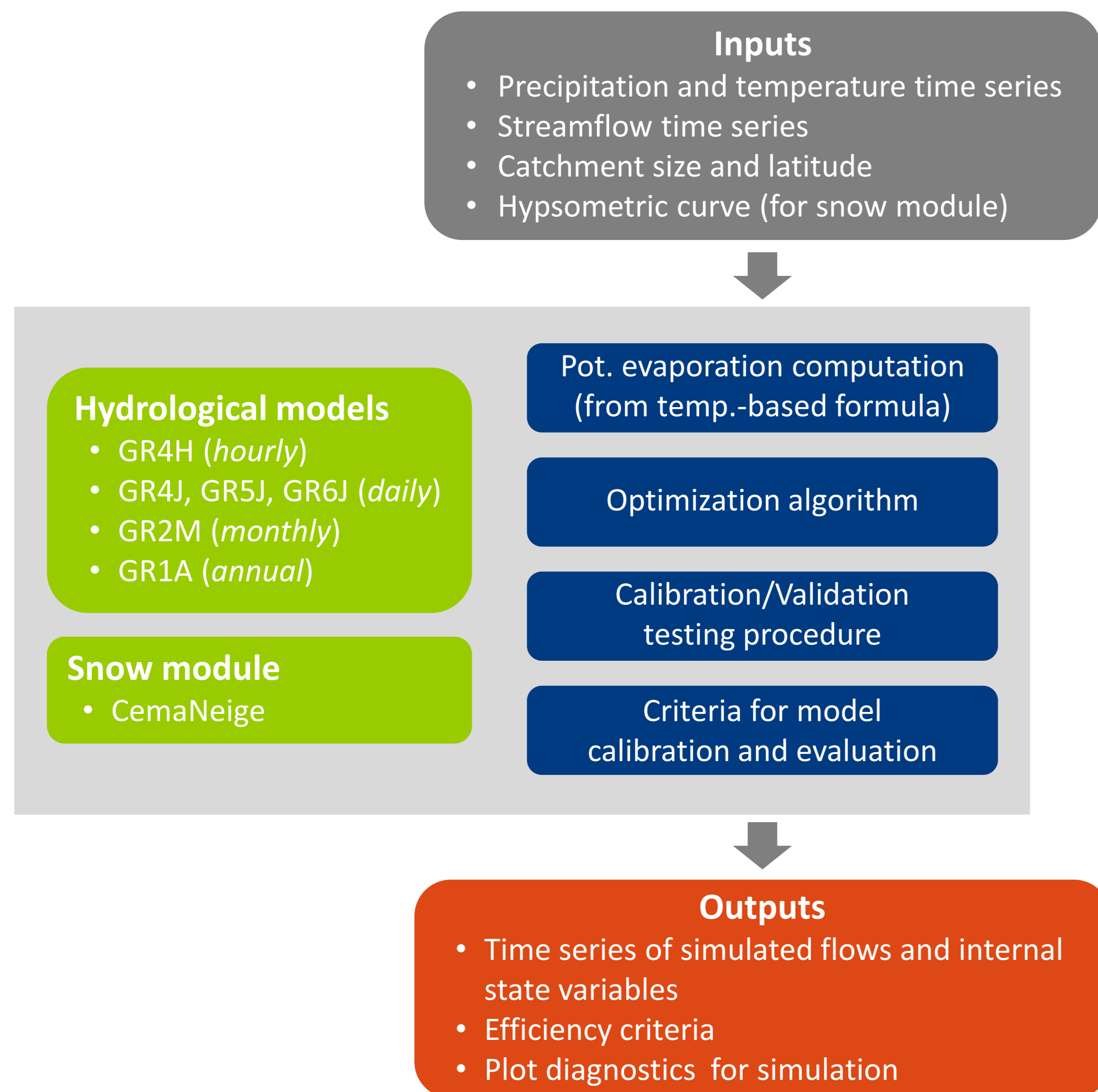
## GR hydrological models

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

## From airGR to airGRteaching

- ▶ The GR hydrological models have been implemented in airGR (Coron *et al.*, 2019)
- ▶ airGRteaching (Delaigue *et al.*, 2019) depends on airGR. It offers simplified functionalities that are particularly suitable for teaching hydrology

## Main components of the airGR package



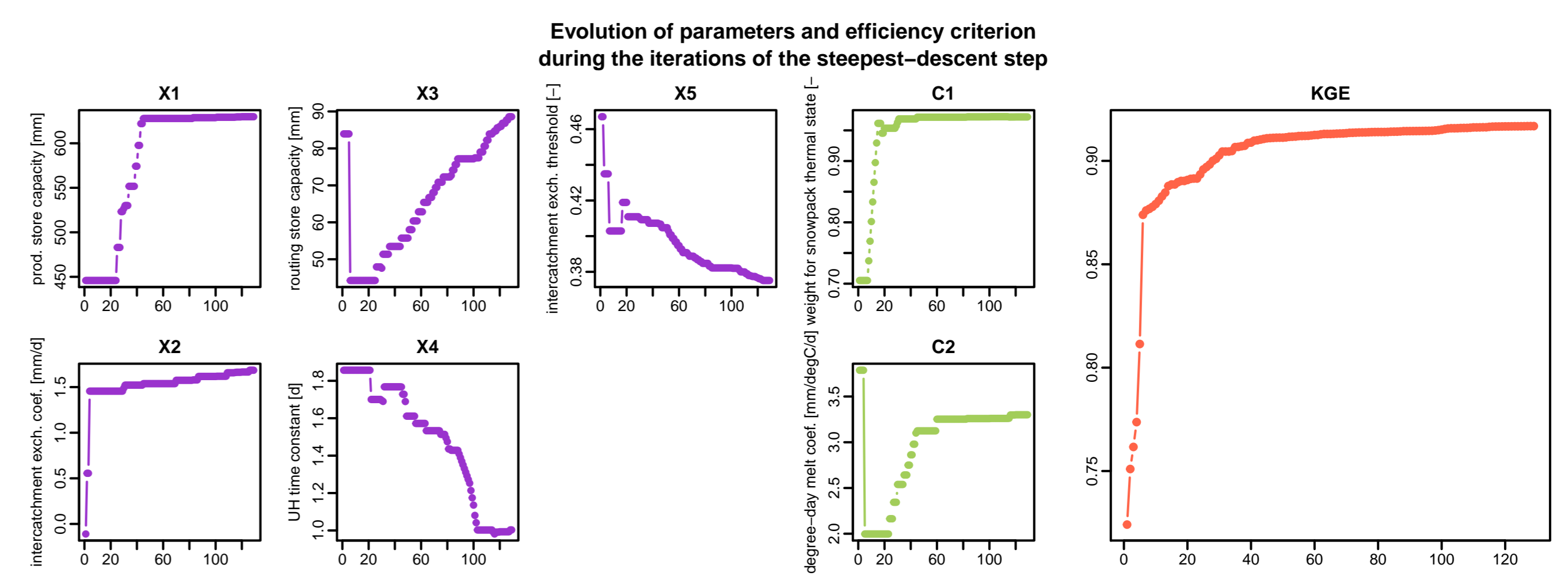
## Data preparation, calibration and simulation with the GR5J model (+ CemaNeige snow module)

```
## data.frame of observed data
data(L0123002)
BasinObs <- BasinObs[, c("Dates", "Precip", "ETP", "Qmm", "Temp")]

## preparation of observed data for modeling
Prep <- PrepGR(ObsDF = BasinObs, HydroModel = "GR5J", CemaNeige = TRUE,
               ZInputs = median(BasinInfo$HypsoData), HypsoData = BasinInfo$HypsoData)

## calibration step
Cal <- CalGR(PrepGR = Prep, CalCrit = "KGE", verbose = FALSE,
            WupPer = NULL, CalPer = c("1990-01-01", "1993-12-31"))
```

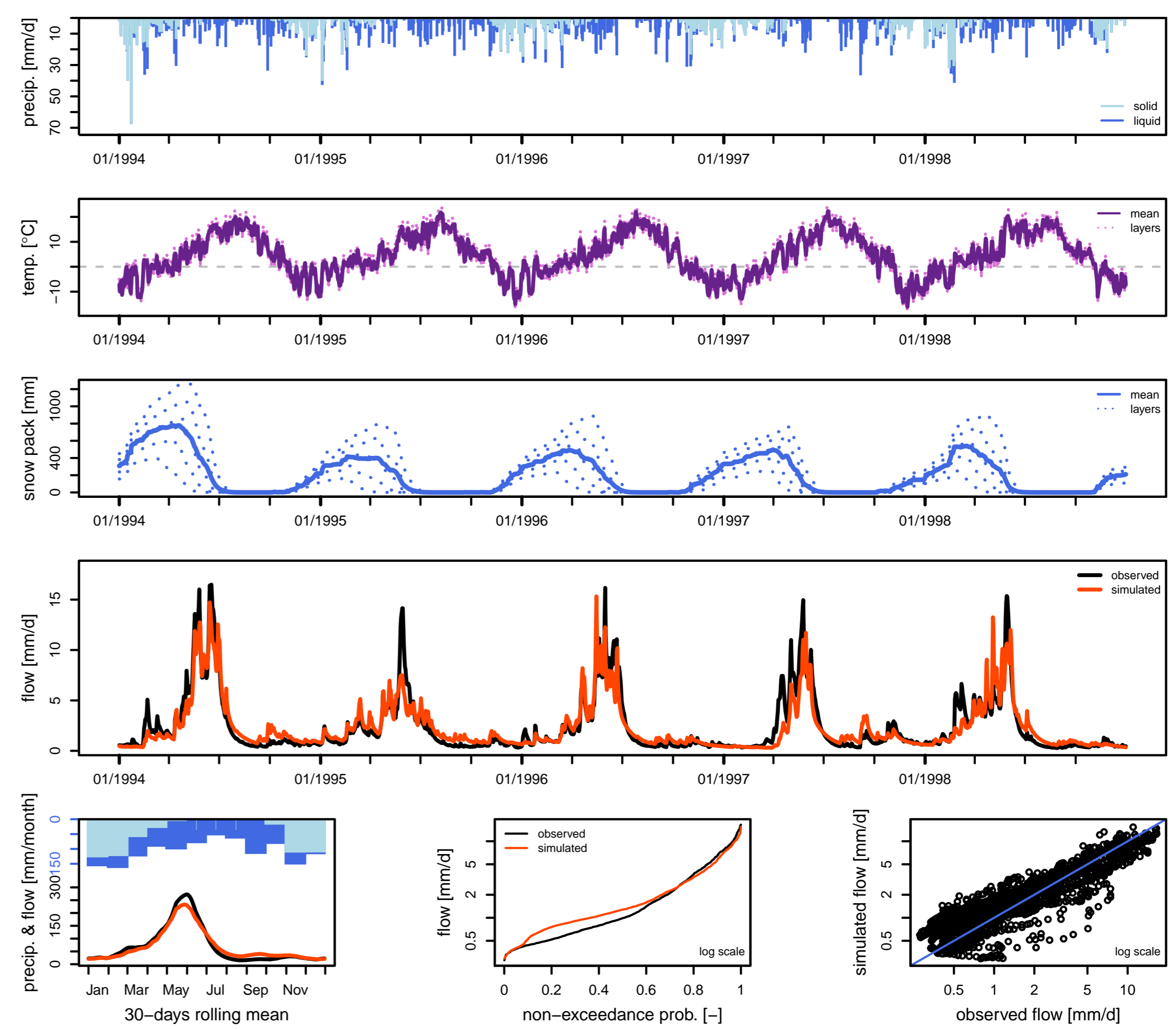
## plot the parameter values and the criterion value during calibration  
plot(Cal, which = "iter")



```
## simulation step using the result of the automatic calibration method
Sim <- SimGR(PrepGR = Prep, CalGR = Cal, EffCrit = "NSE",
            WupPer = NULL, SimPer = c("1994-01-01", "1998-12-31"))
```

## Crit. NSE[Q] = 0.8376

## plot giving an overview of the model outputs  
plot(Sim)



## airGRteaching functionalities

- ▶ The package only requires a basic level of programming
- ▶ Three functions are sufficient to implement the modeling chain:
  - ▷ data preparation (PerpGR())
  - ▷ model calibration (CalGR())
  - ▷ flow simulation (SimGR())
- ▶ Static and dynamic plots can be applied on outputs of aforementioned functions
- ▶ The package proposes a Shiny interface allowing to realize:
  - ▷ simulations of flows by manual modification of parameters
  - ▷ automatic model calibrations
  - ▷ visualization of the internal states of the model

## airGRteaching GUI allowing to understand the roles of parameters and internal variables of models



## airGR websites: get started with the packages or discover advanced uses

- ▶ High degree of customization with airGR
  - ▷ <https://hydrogr.github.io/airGR/>
- ▶ Simple features to learn hydrology with airGRteaching
  - ▷ <https://hydrogr.github.io/airGRteaching/>

## References

- ▶ Coron L., Delaigue, O., Thirel, G., Perrin C., Michel C. (2019). airGR: Suite of GR Hydrological Models for Precipitation-Runoff Modelling. R package version 1.2.13.16. URL: <https://CRAN.R-project.org/package=airGR>.
- ▶ Delaigue, O., Coron, L. and Brigode, P. (2019). airGRteaching: Teaching Hydrological Modelling with GR (Shiny Interface Included). R package version 0.3.6.29. URL: <https://CRAN.R-project.org/package=airGRteaching>.
- ▶ Slater, L., Thirel, G., Harrigan, S., Delaigue, O., Hurley, A., Khouakhi, A., Prodocimi, I., Vitolo, C. & Smith, K. (2019). Using R in hydrology: a review of recent developments and future directions. Hydrology and Earth System Sciences, 1-33. DOI: 10.5194/hess-2019-50.

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