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

Olivier Delaigue, Guillaume Thirel, Laurent Coron, Pierre Brigode

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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.

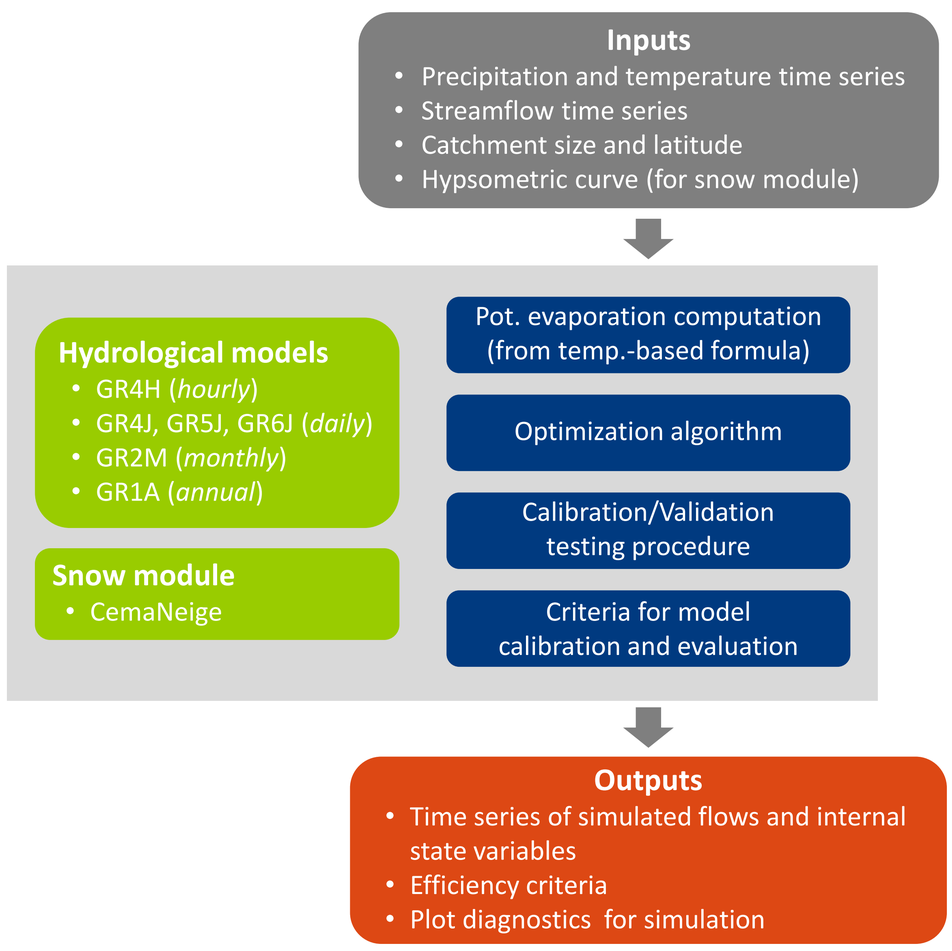
GR hydrological models

- 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



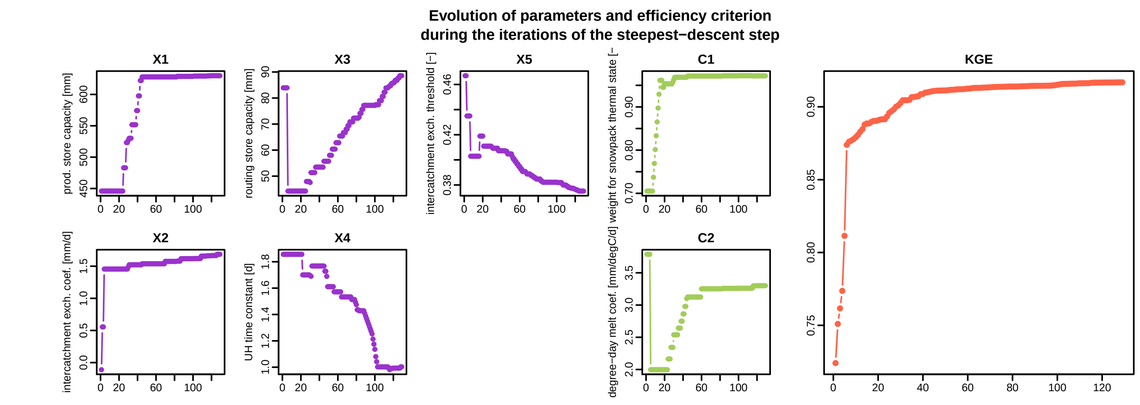
airGRteaching functionalities

- 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 aforementionned 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

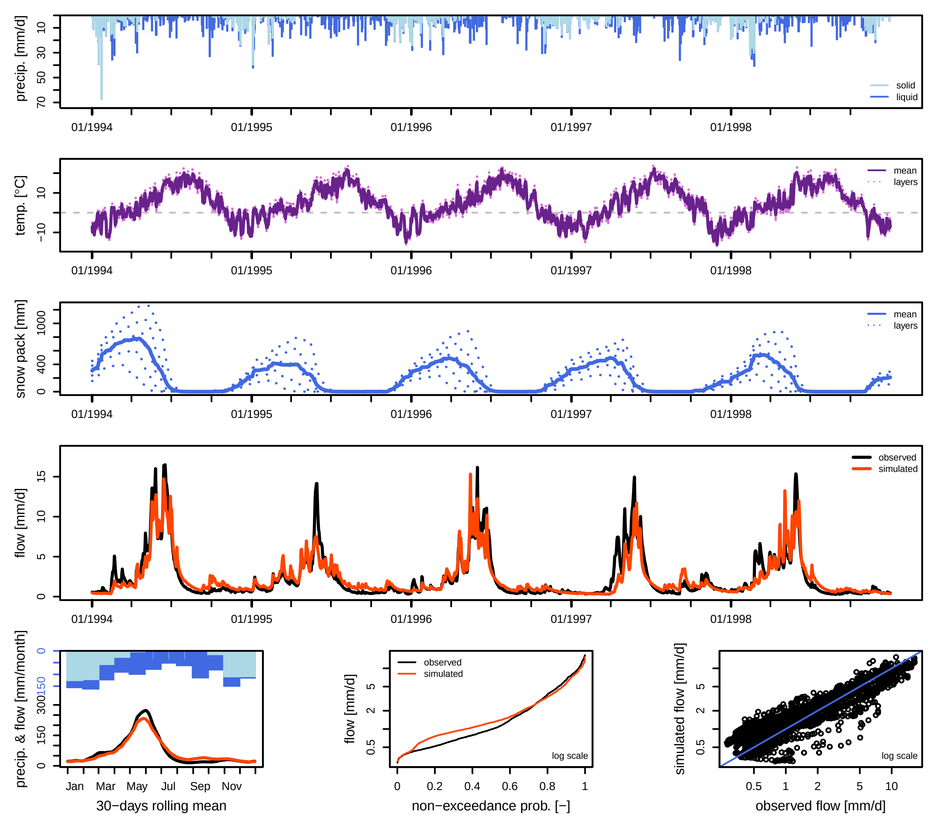
airGRteaching GUI allowing to understand the roles of parameters and internal variables of models

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)
```



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., Prodoscimi, 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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