Using the airGRteaching R package for hydrology courses using lumped hydrological models

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airGRteaching (Delaigue *et al.*, 2018) is an add-on package to the airGR package (Coron *et al.*, 2017). It includes the GR rainfall-runoff models and the CemaNeige snow melt and accumulation model. This package is easy to use and provides graphical devices to help students to explore data and analyse modelling results.

Why using airGRteaching for teaching hydrological modelling?

- It offers an interactive interface to showcase the rainfall-runoff model components
- It can be run with your own data
- It uses fast-running conceptual GR models (annual to hourly time steps)
- Free and open-source, available on all platforms (Linux, Mac OS & Windows)

airGRteaching functionalities

- very low programming skills needed
- only three functions to complete a hydrological modelling exercise:
  - data preparation (requires few input variables)
  - model calibration
  - flow simulation
- plotting functions to help students to explore observed data and to interpret results:
  - static graphs ('graphics' package)
  - interactive graphs ('dygraphs' package)
  - plot functions automatically recognize the airGRteaching objects
- a 'Shiny' graphical interface for (only daily models available):
  - displaying the impact of model parameters on hydrographs
  - manual and automatic model calibration
  - state variable visualisation

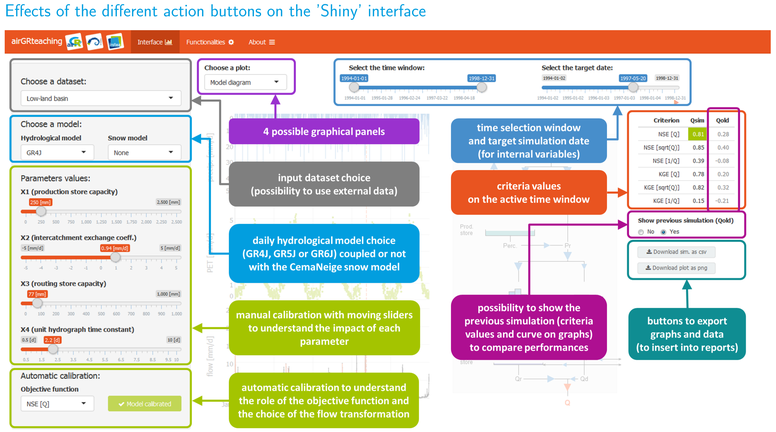
Getting started with the package

- Documentation available with the R command: `vignette("airGRteaching")`
- airGR Website: https://webgr.irstea.fr/en/airGR/

Download the airGRteaching package

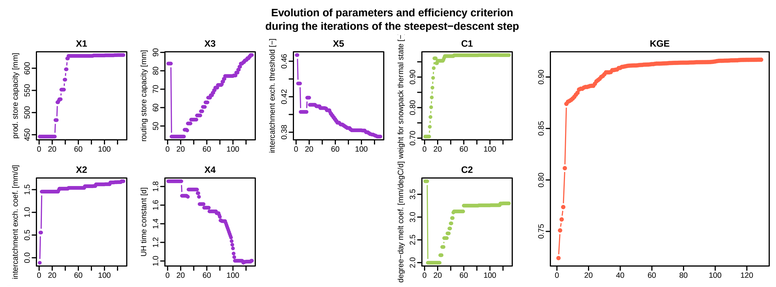
- Freely available on the Comprehensive R Archive Network: https://CRAN.R-project.org/package=airGRteaching/

Effects of the different action buttons on the 'Shiny' interface

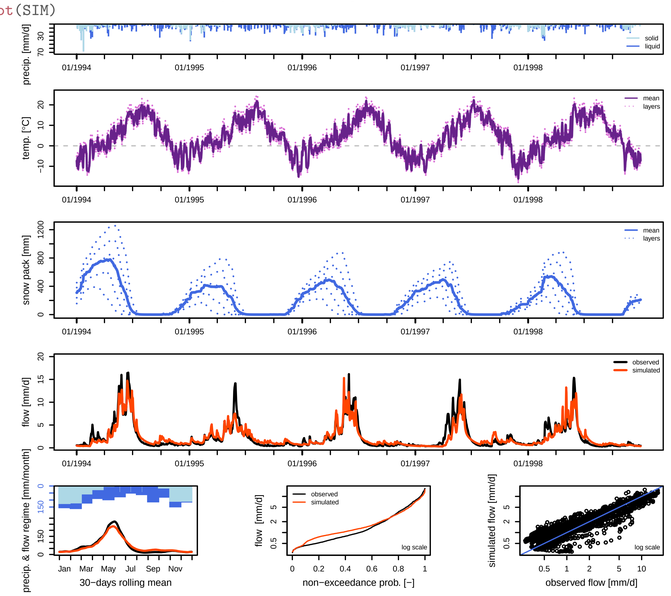


Data preparation, calibration and simulation with the GR5J model (+ CemaNeige snow model)

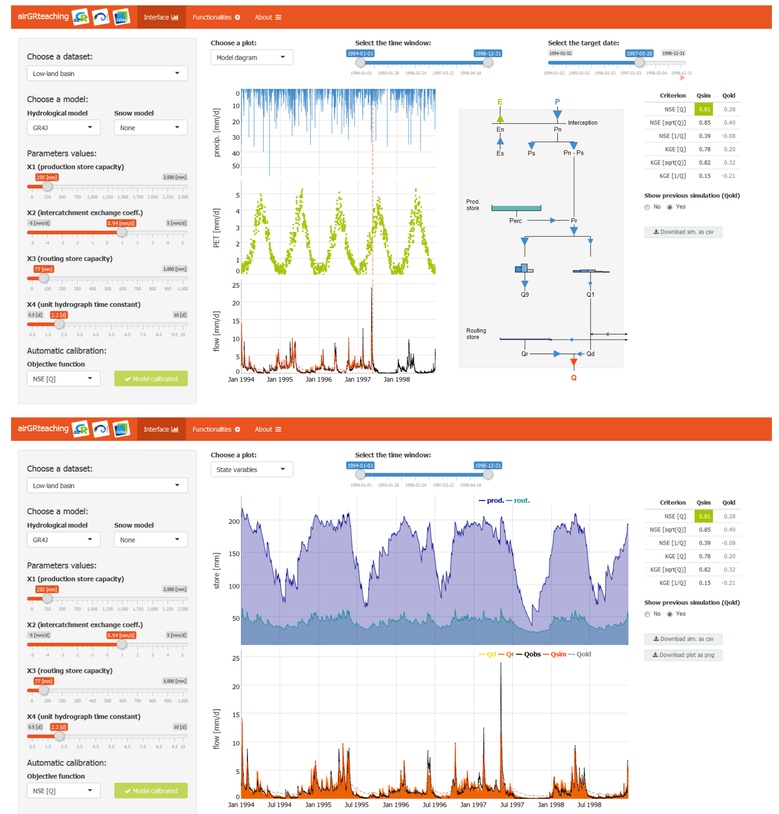
```
## data.frame of observed data
data(L0123002)
BasinObs2 <- BasinObs[, c("DatesR", "P", "E", "Qmm", "T")]

## Preparation of observed data for modelling
PREP <- PrepGR(ObsDF = BasinObs2, 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 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)
```



'Model diagram' & 'State variables' panels of the 'Shiny' interface



Future developments

- Additional models in the 'Shiny' interface (GR2M & GR4H)
- New plots to visualize snow simulation in the 'Shiny' interface

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.
- 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/.
- Delaigue, O., Thirel, G., Coron, L. & Brigode, P. (under review). airGR and airGRteaching: two open-source tools for rainfall-runoff modeling and teaching hydrology. HIC2018 proceedings, 13th International conference of Hydroinformatics, July 2018, Palermo, Italy.

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