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## 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

The screenshot shows the airGRteaching Shiny interface with several callouts explaining the effects of different buttons:

- 4 possible graphical panels:** A dropdown menu to select the plot type (Model diagram, State variables, etc.).
- input dataset choice (possibility to use external data):** A dropdown menu to select the dataset (Low-land basin).
- daily hydrological model choice (GR4J, GR5J or GR6J) coupled or not with the CemaNeige snow model:** A dropdown menu to select the hydrological model and snow model.
- manual calibration with moving sliders to understand the impact of each parameter:** Sliders for parameters X1, X2, X3, and X4.
- automatic calibration to understand the role of the objective function and the choice of the flow transformation:** A dropdown menu for the objective function (NSE [Q]).
- time selection window and target simulation date (for internal variables):** Date pickers for the time window and target date.
- criteria values on the active time window:** A table showing NSE, KGE, and other criteria for different time windows.
- possibility to show the previous simulation (criteria values and curve on graphs) to compare performances:** A checkbox to show the previous simulation.
- buttons to export graphs and data (to insert into reports):** Buttons for 'Download sim. as csv' and 'Download plot as png'.

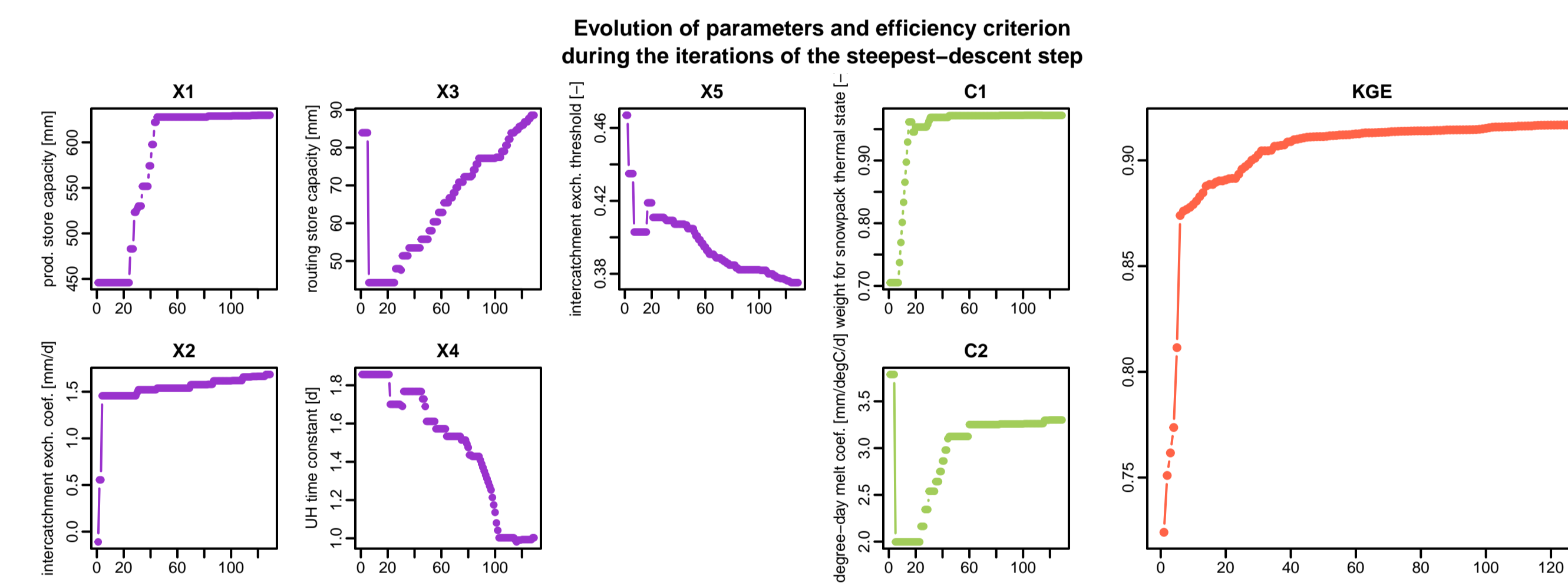
## Data preparation, calibration and simulation with the GR5J model (+ CemaNeige snow model)

```
## 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"))
```

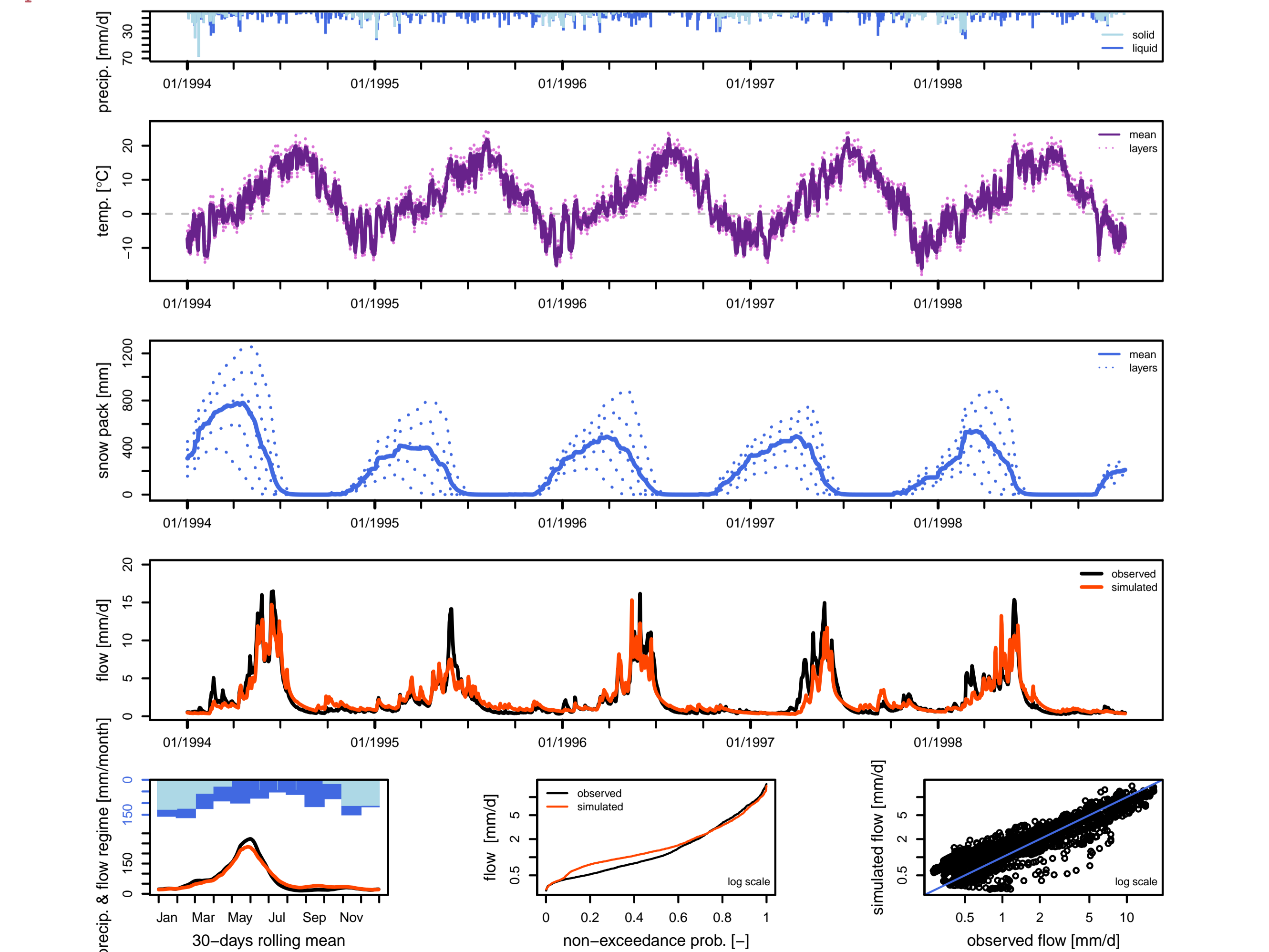
```
## Plot the parameter values and the criterion during calibration
plot(CAL, which = "iter")
```



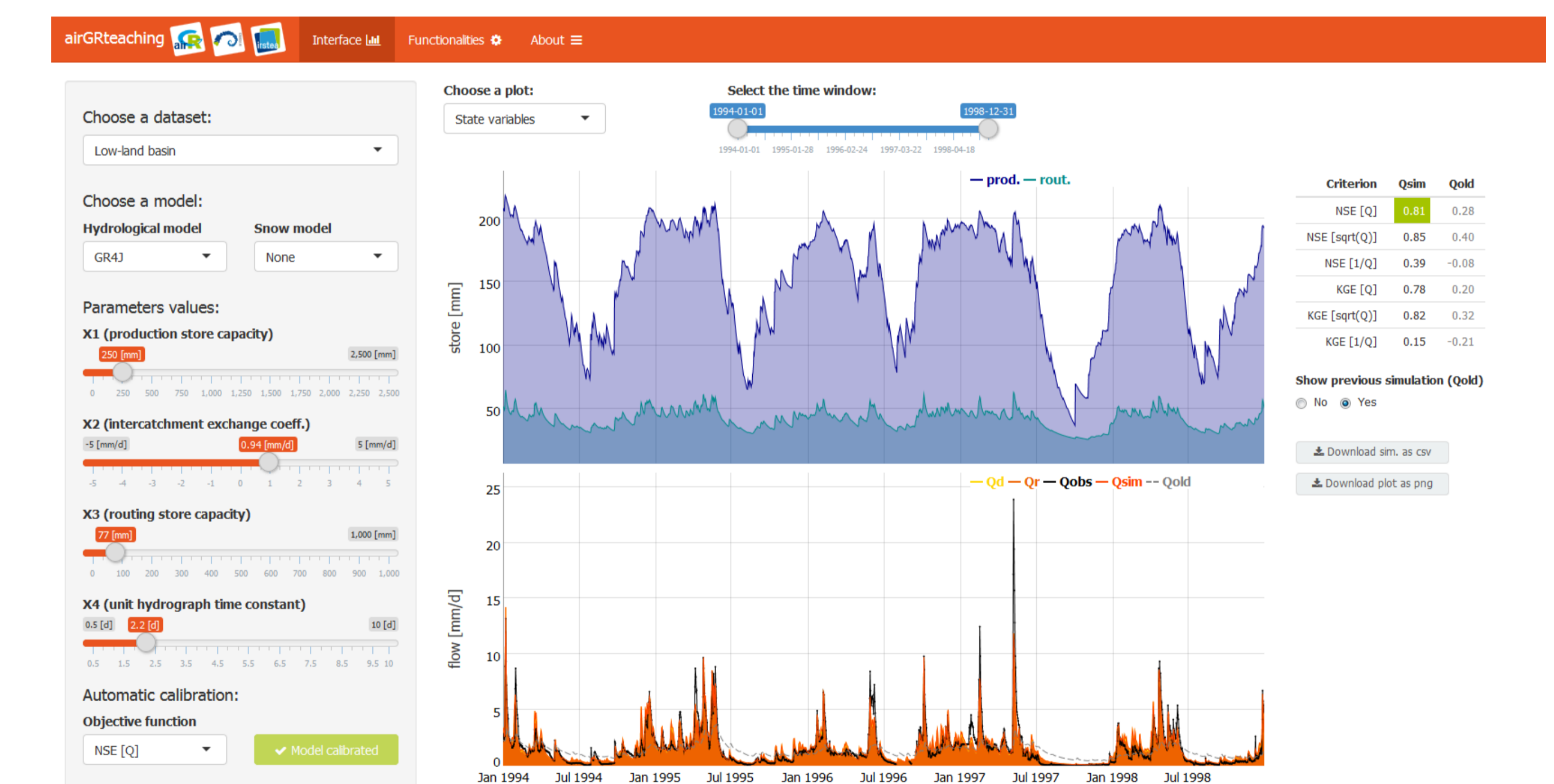
```
## Simulation step using the result of the automatic calibration method
SIM <- SimGR(PrepGR = PREP, CalGR = CAL, EffCrit = "NSE",
            WupPer = NULL, SimPer = c("1994-01-01", "1998-12-31"))
```

```
## 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.