Latest developments of the airGR rainfall-runoff modelling R-package: inclusion of an interception store in the hourly model

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airGR rainfall-runoff modelling R-package

Inclusion of an interception store in the GR5H hourly model

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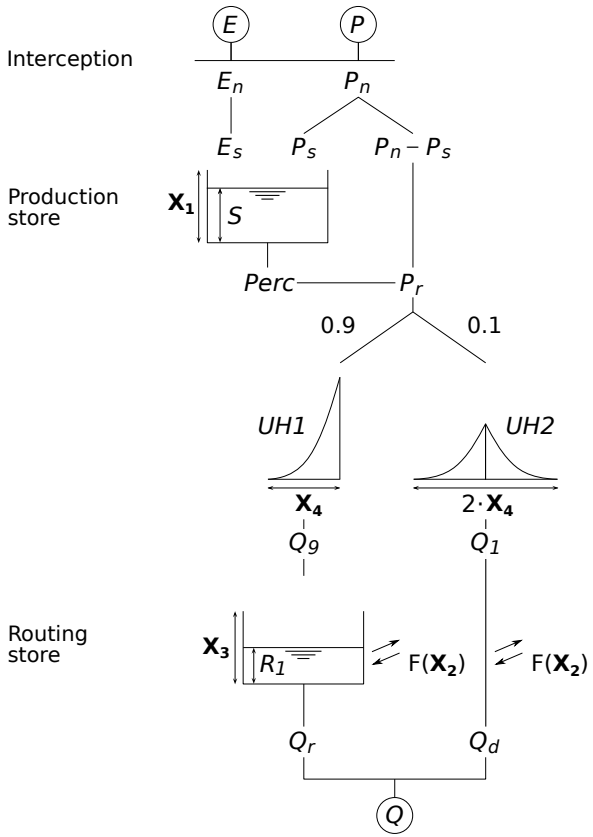
Overview

GR is a family of **lumped hydrological models** designed for streamflow simulation at various time steps

The models are freely available in an **R-package** called **airGR** (Coron et al., 2017, 2020)

The models can easily be implemented on a set of catchments with limited data requirements



GR4J model diagram

Overview

The airGR package

- Package for the R language
- Freely available on the Comprehensive R Archive Network
  `https://CRAN.R-project.org/package=airGR`

The GR hydrological models

- Designed with the objective to be as efficient as possible for streamflow 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)

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New features

New features since EGU-2019

- New **GR5H** model (cf. Ficchi *et al.*, 2019):
  - new model structure with interception store for improved consistency and performance
  - can be coupled with the **CemaNeige** snow module
  - new `Imax()` function allowing to estimate the maximum capacity of the interception store
- The **GR4H** model can be coupled with **CemaNeige**
- The `plot()` function now allows to display new time series:
  - actual evapotranspiration
  - streamflow error
- The `CreateInputsCrit()` function allows new streamflow transformations:
  - power (negative or positive)
  - Box-Cox
- A DOI allows to identify the package manual (in addition of the scientific article)

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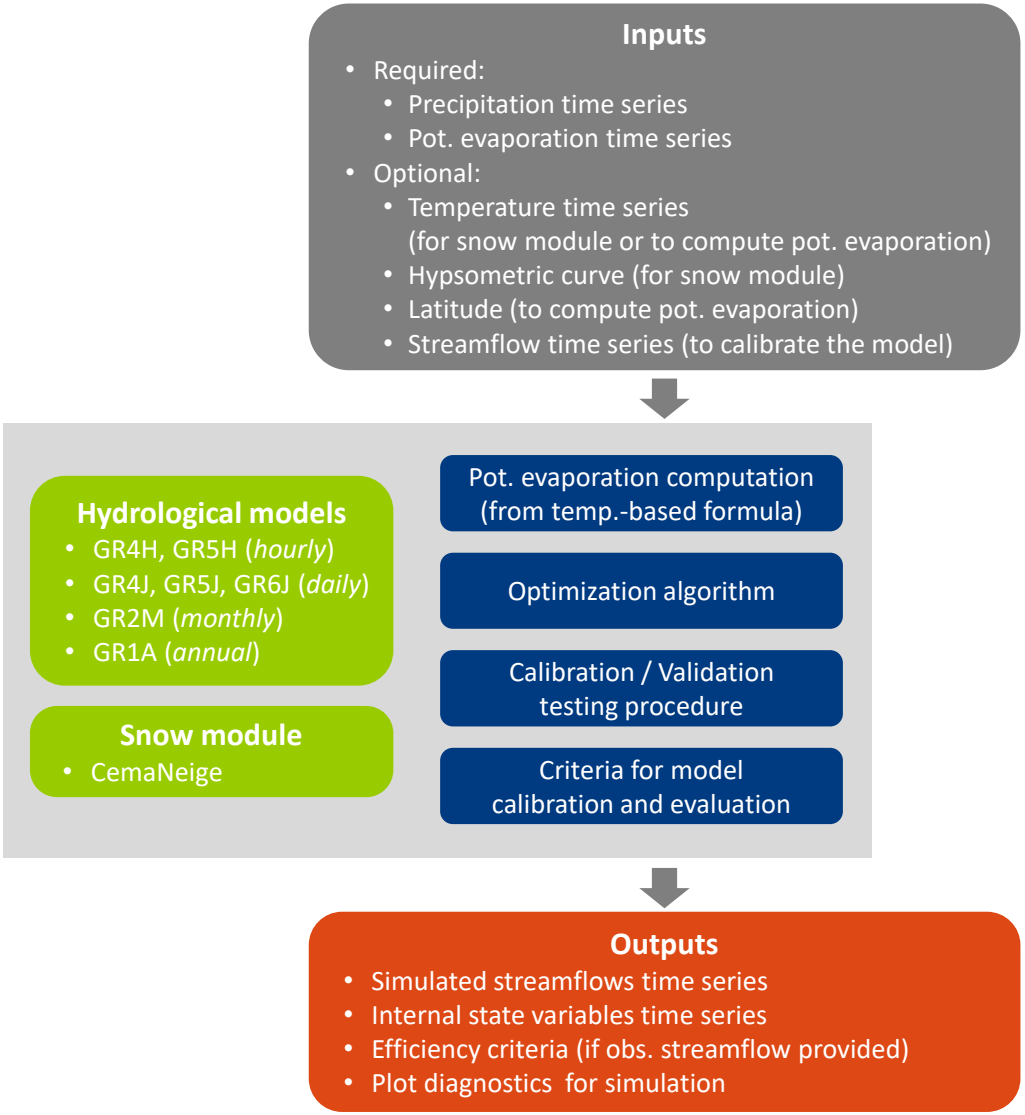
Main components of the airGR package



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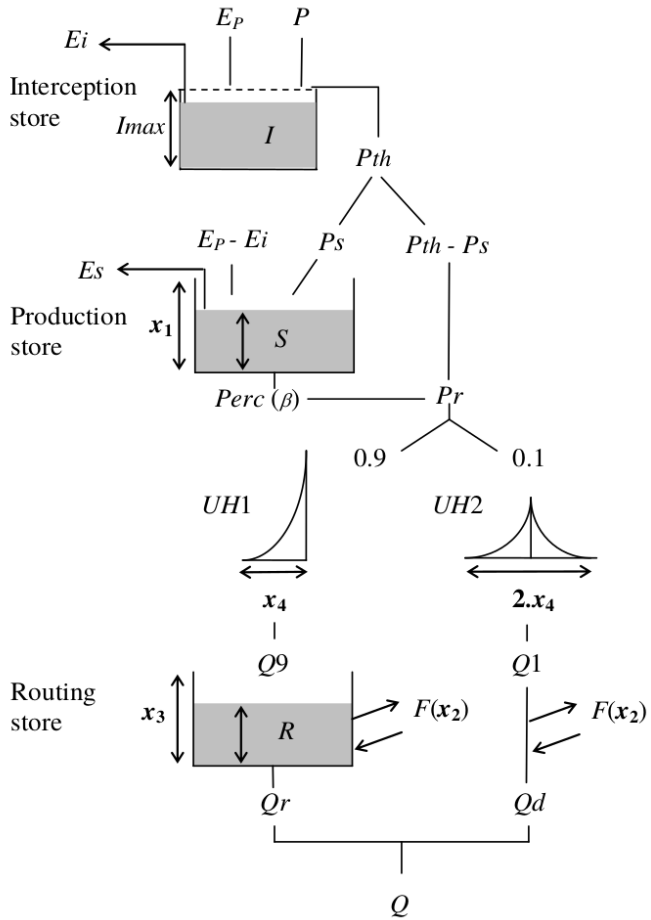
GR5H: hourly model with a new interception store

Aims

- Better representation of the impact of vegetation on evaporation fluxes
- Improved model showed a better consistency of model fluxes over time (stable water fluxes across time steps respecting mass conservation)
- Finer representation of the interception processes at the hourly time step
- Higher model performance proved over a wide range of catchments with particularly improved bias, especially over high flows
- Model parameters become more robust and stable (across time steps) as the flux-matching condition is satisfied



Hands-on in R: inputs preparation

```
## package loading
library(airGR)

## load of catchment data
data(L0123003)

## preparation of the InputsModel object
InputsModel <- CreateInputsModel(FUN_MOD = RunModel_GR5H,
                                 DatesR  = BasinObs$DatesR,
                                 Precip  = BasinObs$P,
                                 PotEvap = BasinObs$E)

## run period selection
Ind_Run <- seq(which(format(BasinObs$DatesR, format = "%Y-%m-%d %H")=="2006-01-01 00"),
               which(format(BasinObs$DatesR, format = "%Y-%m-%d %H")=="2007-12-31 23"))
```

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Hands-on in R: run options

Imax

- It represents the maximum capacity of the interception store
- Its value is adjusted to match the fluxes simulated by the GR4J daily model (neutralisation of precipitation and potential evapotranspiration)

```
## Imax computation
Imax <- Imax(InputsModel = InputsModel,
             IndPeriod_Run = Ind_Run,
             TestedValues = seq(from = 0, to = 3, by = 0.2))

## preparation of the RunOptions object
RunOptions <- CreateRunOptions(FUN_MOD = RunModel_GR5H,
                               InputsModel = InputsModel,
                               IndPeriod_Run = Ind_Run,
                               Imax = Imax)
```

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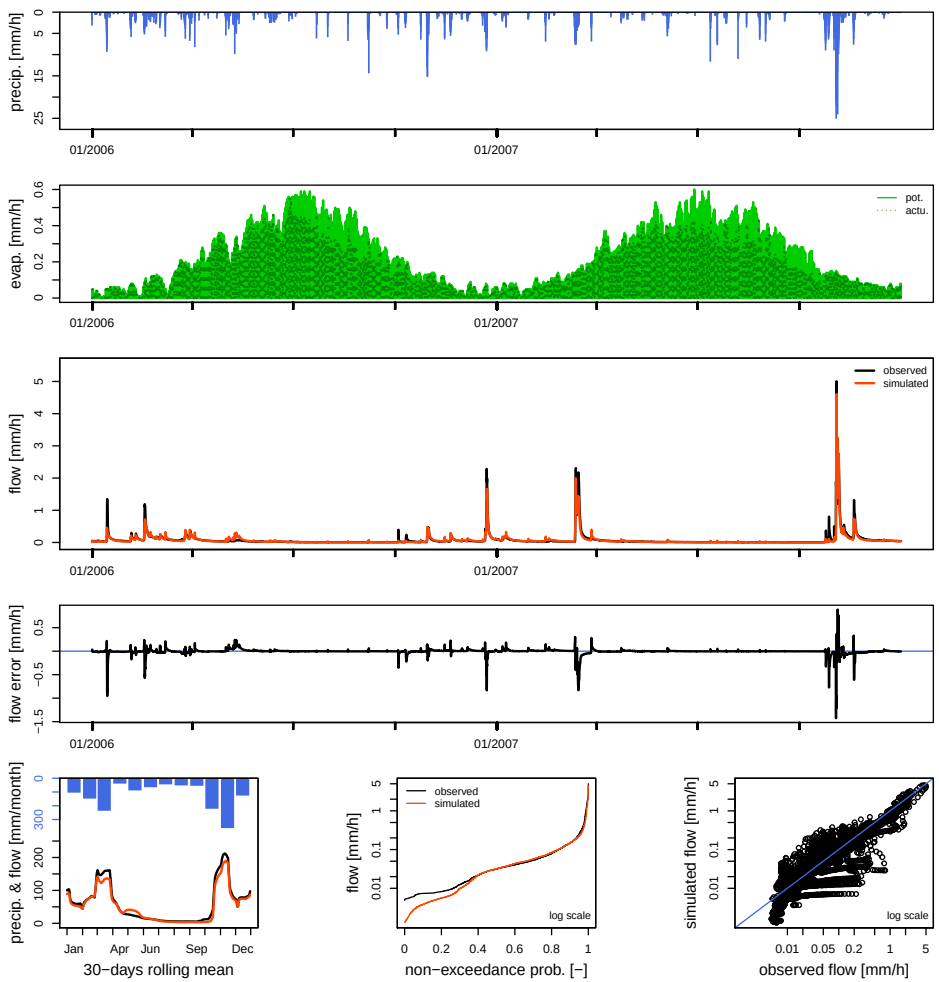
Hands-on in R: simulation

```
## parameter set (can come from an automatic calibration)
Param <- c(X1 = 706.912, X2 = -0.163, X3 = 188.880, X4 = 2.575, X5 = 0.104)

## simulation
OutputsModel <- RunModel_GR5H(InputsModel = InputsModel,
                              RunOptions = RunOptions,
                              Param = Param)
```

Hands-on in R: graphical assessment of the results

```
## results preview
plot(OutputsModel, Qobs = BasinObs$Qmm[Ind_Run], which = "all")
```



Hands-on in R: numerical assessment of the results

```
## efficiency criterion preparation
InputsCrit  <- CreateInputsCrit(FUN_CRIT = ErrorCrit_NSE,
                                InputsModel = InputsModel,
                                RunOptions = RunOptions,
                                Obs = BasinObs$Qmm[Ind_Run])

## efficiency criterion computation
OutputsCrit <- ErrorCrit_KGE(InputsCrit = InputsCrit,
                             OutputsModel = OutputsModel)
## Crit.  KGE[Q] = 0.8386
## SubCrit.  KGE[Q] cor(sim, obs, "pearson") = 0.9505
## SubCrit.  KGE[Q] sd(sim)/sd(obs)          = 0.8748
## SubCrit.  KGE[Q] mean(sim)/mean(obs)      = 0.9110
```

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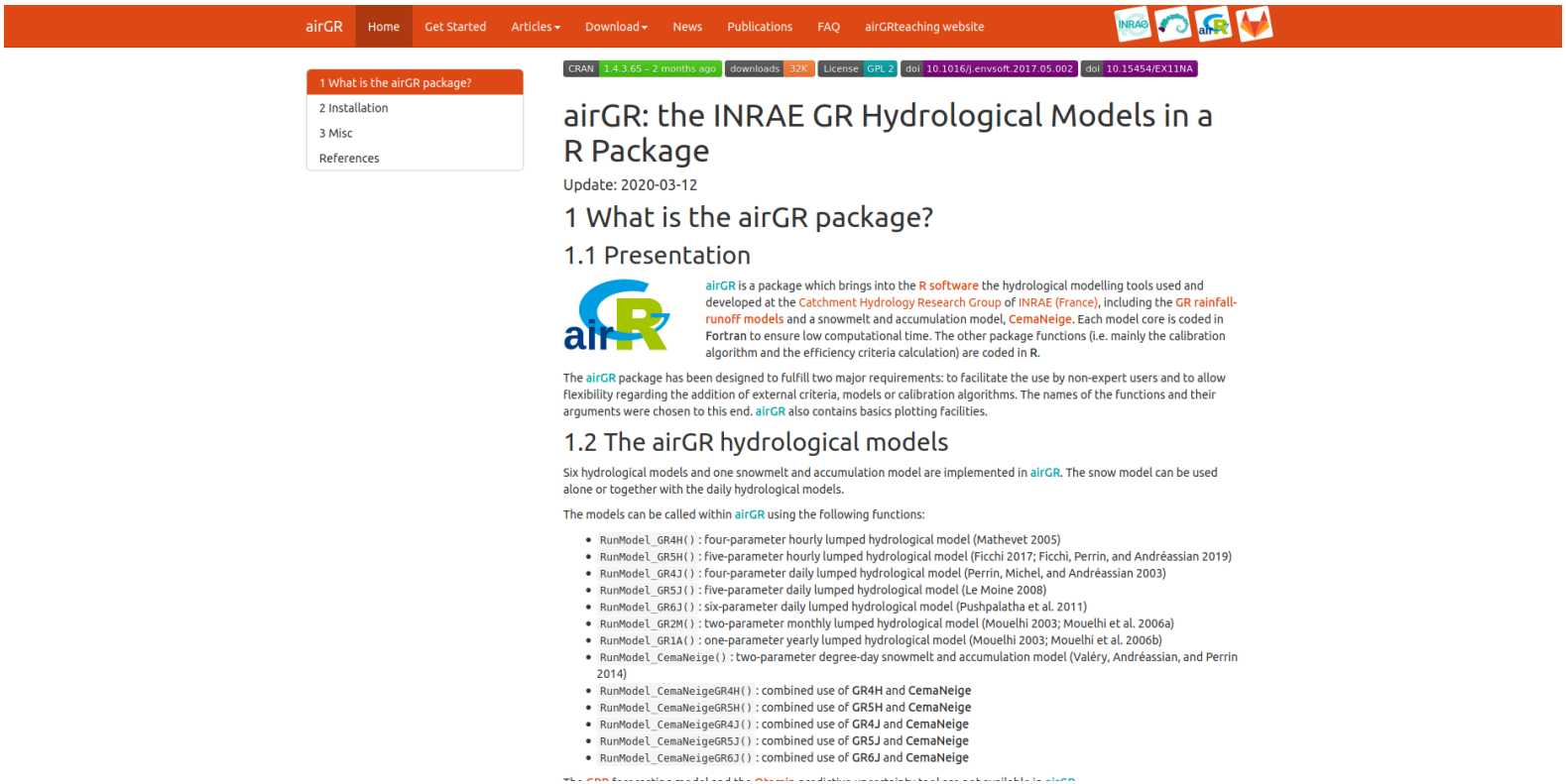
Website

Tutorials & package news

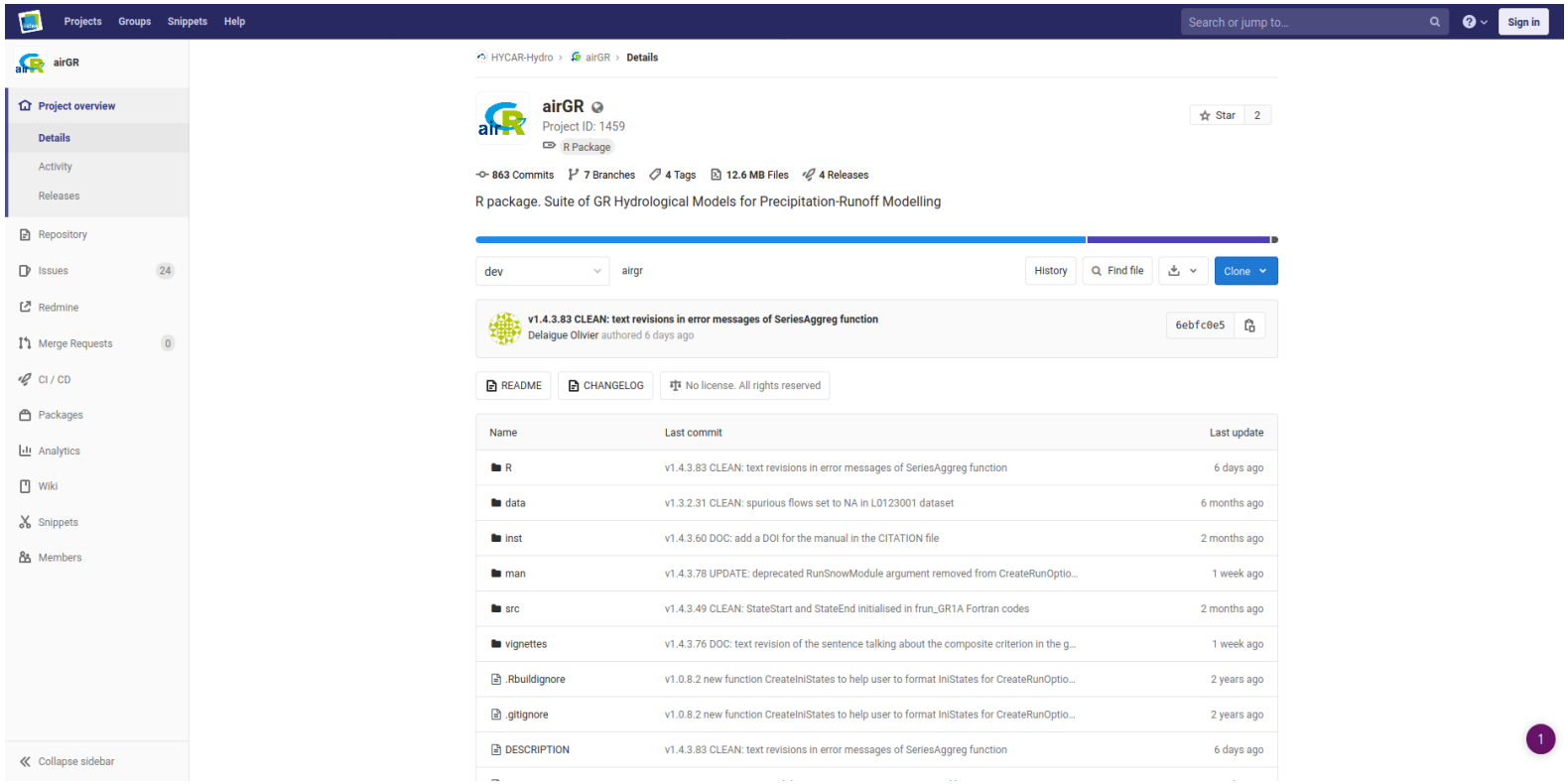
- `https://hydrogr.github.io/airGR/`



Version control

Software development activities (needs & bug reports)

- `https://gitlab.irstea.fr/HYCAR-Hydro/airGR`



airGR & airGRteaching packages

	airGRteaching (GUI)	airGRteaching (code)	airGR
Working environment			
Graphical user interface	yes	no	no
Use of programming	no	yes (simplified)	yes (advanced)
Dynamic graphics outputs	yes	yes	no
Static graphic outputs	yes	yes	yes
Models			
Daily GR models	yes	yes	yes
Other GR models	no	yes	yes
External models	no	no	yes
CemaNeige with hysteresis using SCA & SWE	no	no	yes
Choice of initialization of internal states	no	no	yes
Criteria and calibration			
NSE and KGE criteria	yes	yes	yes
RMSE and KGE' criteria	no	yes	yes
Composite criteria (defined by the user)	no	no	yes
Calculation of criteria over discontinuous periods	no	no	yes
Freedom of parameter values	no	yes	yes
Adaptation of the calibration options	no	yes (simplified)	yes (advanced)
Other calibration algorithms (defined by the user)	no	no	yes

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airGR & GR5H references

airGR package

- Coron, L., Thirel, G., Delaigue, O., Perrin, C. and Andréassian, V. (2017). The Suite of Lumped GR Hydrological Models in an R package. Environmental Modelling and Software, 94, 166-171. DOI: 10.1016/j.envsoft.2017.05.002.
- Coron, L., Delaigue, O., Thirel, G., Perrin, C. and Michel, C. (2020). airGR: Suite of GR Hydrological Models for Precipitation-Runoff Modelling. R package version 1.4.3.65. URL: `https://CRAN.R-project.org/package=airGR`, DOI: 10.15454/EX11NA.

The new GR5H model with interception store

- Ficchì, A., Perrin, C., and Andréassian, V. (2019). Hydrological modelling at multiple sub-daily time steps: model improvement via flux-matching, Journal of Hydrology, 575, 1308-1327. DOI: 10.1016/j.jhydrol.2019.05.084.

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