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airGRteaching: an R-package designed for teaching hydrology with lumped hydrological models

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Lumped hydrological models are useful and convenient tools for research, engineering and educational purposes. They propose catchment-scale representations of the precipitation-discharge relationship. Thanks to their limited data requirements, they can be easily implemented and run. With such models, it is possible to simulate a number of hydrological key processes over the catchment with limited structural and parametric complexity, typically evapotranspiration, runoff, underground losses, etc.
The Hydrology Group at Irstea (Antony) has been developing a suite of rainfall-runoff models over the past 30 years. This resulted in a suite of models running at different time steps (from hourly to annual) applicable for various issues including water balance estimation, forecasting, simulation of impacts and scenario testing.
Recently, Irstea has developed an easy-to-use R-package (R Core Team, 2016), called airGR (Coron et al., 2016, 2017), to make these models widely available.
Although its initial target public was hydrological modellers, the package is already used for educational purposes. Indeed, simple models allow for rapidly visualising the effects of parameterizations and model components on flows hydrographs. In order to avoid the difficulties that students may have when manipulating R and datasets, we developed (Delaigue and Coron, 2016):
- Three simplified functions to prepare data, calibrate a model and run a simulation
- Simplified and dynamic plot functions
- A shiny (Chang et al., 2016) interface that connects this R-package to a browser-based visualisation tool.
On this interface, the students can use different hydrological models (including the possibility to use a snow-accounting model), manually modify their parameters and automatically calibrate their parameters with diverse objective functions. One of the visualisation tabs of the interface includes observed precipitation and temperature, simulated snowpack (if any), observed and simulated discharges, which are updated immediately (a calibration only needs a couple of seconds or less, a simulation is almost immediate). In addition, time series of internal variables, live-visualisation of internal variables evolution and performance statistics are provided.
This interface allows for hands-on exercises that can include for instance the analysis by students of:
- The effects of each parameter and model components on simulated discharge
- The effects of objective functions based on high flows- or low flows-focused criteria on simulated discharge
- The seasonality of the model components.

References

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