Rainfall-runoff model to estimate low-flow indices

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Objectives: To develop a daily rainfall-runoff model, with few parameters to simulate low-flow indices at gauged and ungauged sites and under different climate conditions.

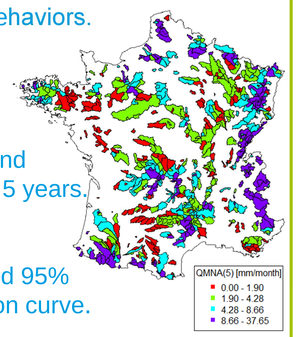
1. Introduction

- Low flows are characterized by different indices that are needed to manage water resources at gauged and ungauged sites.
- Low-flow indices are statistics derived from measured or simulated discharges.
- A monthly regionalized rainfall-runoff model (LoiEauM) was developed by Irstea to estimate monthly indices at ungauged sites.
- Needs to adapt the model structure and regionalize its parameters to estimate daily indices at ungauged sites.

2. Dataset and methods

Dataset

- Daily meteorological data come from the SAFRAN reanalysis of Météo-France and daily streamflow data from the French database HYDRO.
- Set of 691 catchments throughout France, natural or with small human influences, with various hydro-meteorological behaviors.

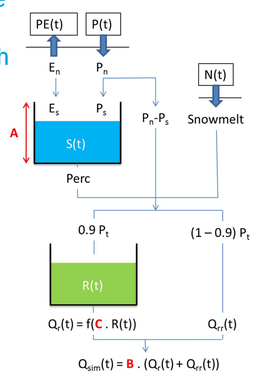


Low-flow indices

- MAR: mean annual runoff.
- QMM: seasonality (mean monthly runoff).
- MAM3(5) and MAM10(5): mean annual 3-d and 10-d minimum flow at the recurrence interval of 5 years.
- QMNA(5): annual mean monthly flow at the recurrence interval of 5 years.
- Q95 and Q75: discharge equaled or exceeded 95% and 75% of the time, come from the flow duration curve.

Methods

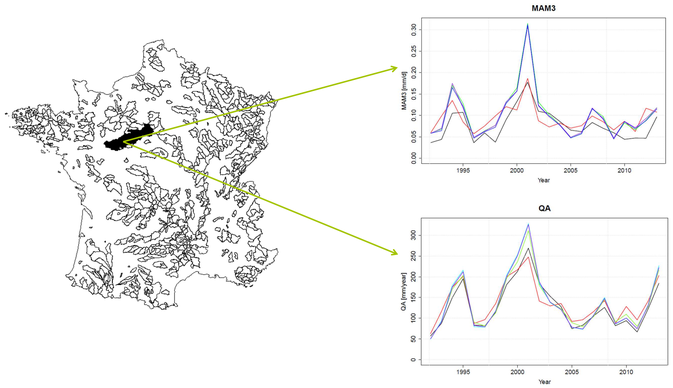
- Daily model structure (LoiEauJ) derived from the monthly model LoiEauM, which has 2 parameters.
- 2 structures: one with 3 parameters and one with 2 parameters (parameter A regionalized).
- Split sample test procedure, cross-validation on 2 subperiods: 1970 – 1981 and 1982 – 2013.
- Objective function: $\frac{1}{2}KGE(Q) + \frac{1}{2}KGE\left(\frac{1}{Q}\right)$.
- Evaluation of the low-flow index simulations.
- Evaluation of the robustness of the model.
- Comparison with the low-flow indices simulated with the daily models GR4J (4 parameters) and GR3J (3 parameters) and the monthly model LoiEauM.



3. Results

Comparison for one catchment

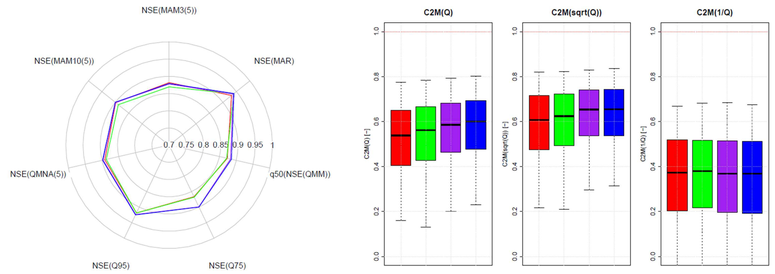
- Better simulations of MAM3 and QA (annual runoff), in validation with the model LoiEauJ with 2 parameters for the Loir River at Durtal.



Legends of the models

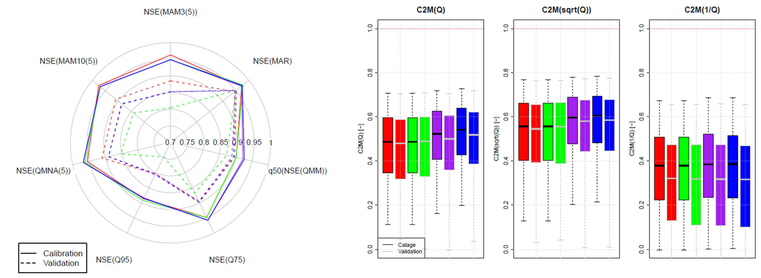
- LoiEauJ (2 parameters)
- GR3J (3 parameters)
- LoiEauM (2 parameters)
- LoiEauJ (3 parameters)
- GR4J (4 paramaters)

Comparison of the models for the catchment set



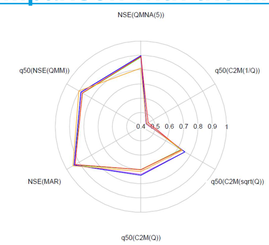
- Good simulations of the low-flow indices with the two LoiEauJ models.
- Better simulations of high flows, C2M(Q), and intermediary flows, C2M(sqrt(Q)), with the model LoiEauJ with 3 parameters. ($C2M = {}^{NSE}/_{(2-NSE)}$).
- No differences between the two LoiEauJ for the low-flow simulations, C2M(1/Q).
- The performances of the two LoiEauJ are as good as the ones with GR3J and GR4J.

Robustness of the models



- Calibration on the 22 driest years and validation on the 22 wettest ones, then the periods are exchanged.
- The LoiEauJ model with 2 parameters is more robust for the low-flow index simulations.
- The LoiEauJ models are more robust for the high-flow and intermediary-flow simulations.
- No differences are observed for the low-flow simulations.

Comparison with the monthly model



- The QMNA(5) and the monthly hydrographs are better simulated with the daily models, the 2 LoiEauJ, GR4J and GR3J, than with the monthly model, LoiEauM.

4. Conclusions, Perspectives

- The low-flow index simulations with the two LoiEauJ models (with 2 and 3 parameters) are as good as the ones with the two GR models (GR4J and GR3J) at gauged sites.
- The model with 2 parameters is more robust than the others.
- The monthly indices are better simulated with the daily models than with the monthly one, at gauged sites.
- The parameters of these models will be regionalized, with spatial proximity interpolations or regressions, and the simulations will be compared at ungauged sites.

References

[1] Folton, N. and Lavabre, J. 2006. Regionalization of a monthly rainfall–runoff model for the southern half of France based on a sample of 880 gauged catchments. *IAHS Publication* n°307, pp. 264-277.

[2] Perrin, C., Michel, C. and Andréassian, V. 2003. Improvement of a parsimonious model for streamflow simulation. *Journal of Hydrology*, 279(1-4), 275-289.

[3] Folton, N. and Arnaud, P. 2012. Cartographie des débits de référence d'étiage sur le territoire national – La méthode LOIEAU. Rapport, Irstea – ONEMA ; 16 pp.

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